# BRINGING TECHNOLOGY TO LIFE

Increasing the amount of in-service medical equipment by developing a MOOC to train Biomedical Equipment Technicians in Low-/ Middle Income Countries

**R.M.H. Rutten**

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## Increasing the amount of in-service Medical Equipment by developing a MOOC to train Biomedical Equipment Technicians in Low-/ Middle Income Countries

by

R.M.H. Rutten

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| Student number: | 4282485 |
| Masters of Science: | Mechanical Engineering (BMD) |
| Thesis committee: | Prof. Dr. J. Dankelman |
| | Dr. Ir. A.J. Knulst |
| | Dr. Ir. J.C. Diehl |
| | Ir. A. Chauhan |

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A real problem in today's world is the use and application of medical and laboratory equipment in developing countries. A few decades ago the focus and emphasize was on the funding and sourcing of equipment, but today's reality is that about half of the equipment is not being used often due to simple to solve technical issues. As the equipment is needed harder than ever before it is essential that this issue is effectively addressed. I am very grateful for having been given the opportunity to participate in thinking about this significant and deeply frustrating topic in my thesis project.

Before you lies the finished product of my master thesis project. This thesis is written as the final stage in the process of obtaining my degree as Master of Science in the field of Biomechanical Design, with Bioinspired Technology as specialization, at the faculty of Mechanical Engineering at Delft University of Technology. The graduation project was realized in a cooperation between the Technical University of Delft, the Nick Simons Institute in Nepal and other contacts willing to help from all over the world.

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*R.M.H. Rutten*
*Amsterdam, October 2020*

# Abstract

Currently between 30% till 50%, some even state up to 70% [1], of medical and laboratory equipment is reported as out of service, due to small or large technical failures or due to missing knowledge of how to use well-functioning equipment in Low-/ Middle- Income Countries (LMIC) [2][3]. This is not due to the complexity of the required repair, but due to, among others, the shortage of sufficiently educated and motivated Biomedical Equipment Technicians (BMETs). This research will focus on the knowledge gap of how to use, maintain and repair medical and laboratory equipment and the missing motivation of BMETs in LMIC by setting up a Pilot Course.

The objective of this research is to verify the possibility to train BMETs in LMIC with the required set of skills and knowledge with an online training and the possibility to intrinsically motivate participants to perform better within an online training, whilst taking local limitations and cultural norms and values into account. Based on the findings, a recommendation will be given for the creation of a Massive Open Online Course (MOOC) to train BMETs in LMIC. In addition, if proven intrinsic motivation can be stimulated during training, the next step would be to prove intrinsic motivation to perform better on the job as BMET can be stimulated during training. In that manner, this research aims to set the first step in decreasing the large number of reported out of service medical and laboratory equipment by closing the knowledge gap and by increasing motivation among future BMETs.

A Pilot Course was created educating participants with knowledge and skills required to use, maintain and repair the Patient Monitor. In addition, several surveys were spread to request expectations, feedback and general input with regards to the development of a MOOC to train BMETs. Within the Pilot Course four cohort groups were created. This research will focus on the distinction between two of the four groups; a group exposed to motivational incentives and a group not exposed to motivational incentives. This distinction must verify the possibility to intrinsically motivate participants to perform better in a Pilot Course. The Pilot Course itself, together with the surveys must give insights on how to design and setup a MOOC to train BMETs in LMIC.

It was found that BMETs can indeed be educated with the set of skills and knowledge exposed to in an online training. There was no significant difference found in performance in the Pilot Course between the different cohort groups and thus no significant impact of the motivational incentives on performance detected. The completion rate was higher for the group not exposed to the motivational incentives. It was also found that the completion rate was higher among participants from South-East Asia compared to Africa, which was not caused by the different cohort groups, but by the propensity to stick to discipline coherent to the Asian culture [22]. No other significant relations or results were found.

Based on these conclusions my recommendation is to create a MOOC to train BMETs in LMIC to close the currently existing knowledge gap. When designing the MOOC, I would recommend using guidelines and recommendations presented in this research. Additionally, I recommend to further investigate the possibility to intrinsically motivate participants during training and thereby influence their behaviour to perform better as a BMET.

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# Abbreviations

| | |
|---|---|
| **BMET** | Biomedical Equipment Technician |
| **CG** | Cohort Groups |
| **CKQ** | Corrected Knowledge Quiz |
| **CKQR** | Corrected Knowledge Quiz Results |
| **CR** | Completion Rate |
| **EFL** | Settings where English is a Foreign Language |
| **FA** | Final Assessment |
| **KQ** | Knowledge Quiz |
| **LMIC** | Low-/ Middle- Income Countries |
| **MOOC** | Massive Open Online Course |
| **ND** | Normal Distribution/ Normally Distributed |
| **NGO** | Non-Governmental Organisation |
| **NSI** | Nick Simons Institute |
| **OEM** | Original Equipment Manufacturer |
| **PM** | Patient Monitor |
| **R** | Pearson product-moment correlation coefficient |
| **TG** | Total Grade |
| **TU** | Technical University |
| **WHO** | World Health Organisation |
| **WTO** | World Trade Organisation |

# 1

# Introduction

Currently between 30% till 50%, some even state up to 70% [1], of medical and laboratory equipment is reported as out of service, due to small or large technical failures or due to missing knowledge how to use well-functioning equipment, in Low-/ Middle- Income Countries (LMIC) [2][3]. This is not due to the complexity of the required repair, but due to, among others, the shortage of sufficiently educated and motivated Biomedical Equipment Technicians (BMETs). Other limitations causing the high number of out of service medical and laboratory equipment are lack of spare parts and consumables, no or very limited infrastructure, lack of equipment and lack of knowledge how to use and maintain equipment [4][5][6]. This research will focus on the knowledge gap of how to use, maintain and repair medical and laboratory equipment and the missing motivation of BMETs in LMIC.

## 1.1. Problem Statement

LMIC are suffering from large percentages of out of service medical and laboratory equipment [2][3]. There are several limitations present in LMIC causing for the large number of out of service medical and laboratory equipment. However, analysing the current situation, literature studies state that by implementing an effective online training, 65% of all out of service medical and laboratory equipment can be repaired, considering local contexts. This indicates local limitations do not have to lead to the high amount of out of service medical and laboratory equipment. The issue can be solved or at least improved, by providing proper training and increasing motivation among BMETs. In summary, the problem addressed by this research is twofold; (1) there is a shortage of properly educated BMETs in LMIC and (2) active and properly trained BMETs miss motivation to perform successfully as BMET.

Let us first elaborate on the most relevant problem mentioned; the shortage of properly educated BMETs. A Biomedical Equipment Technician (BMET) also referred to as Biomedical Engineer, is a trained professional capable of repairing or performing maintenance on medical equipment [2]. A BMET does not need to be highly educated as engineer, only limited skills and knowledge are required. Complex repair or maintenance is supposed to be performed by the manufacturer of the equipment, however structural and preventive maintenance or repair of minor or less complex issues should fall within their capabilities and knowledge set. Therefore, only limited training is necessary to become a BMET. Often a BMET has high school as highest level of education and followed certain applied training afterwards to become a BMET, however, this differs per country and hospital. A BMET should be part of the active hospital staff in every hospital all over the world. Especially in LMIC BMETs have an important role, since assistance and warranty arrangements by the manufacturer often do not exist. The equipment might be donated second hand, meaning contracts with manufactures have expired or contracts are not applicable in different countries or continents. Therefore the responsibility of the BMET within the hospital increases. However, as stated before, in many LMIC there is a shortage of educated BMETs. Therefore, a training must be developed accessible to everyone with at least high school education. A remote training, free of charge, educating potential BMETs with the necessary set of skills and knowledge level.

In addition to an insufficient amount of properly trained BMETs, there is a second problem: Currently active BMETs lack motivation to perform their tasks. One of the most crucial problems currently with BMETs in LMIC is frustration about the working environment and circumstances or the hierarchy and trust within the hospital among staff [4][6]. In addition, consequences of being successful or failing and thus an understanding of the difference between failure and success within their role as a Biomedical Equipment Technician is missing [7]. So there is little incentive to obtain success. Implementing a mechanism in which success is recognised, responsibility morally increased and failure connected to social consequences, will have serious impact on motivation and thus the number of out of service medical and laboratory equipment. This is currently implemented in some hospitals in LMIC led by NGOs. BMETs working in these hospitals have indicated there is a clear job description and recognition increases when being successful [8]. However, this system operates at local scale. If motivation would be stimulated during training, the issue could be improved at global scale instead of local scale. The situation within hospitals and the surroundings of the BMET cannot be changed by an online training, but the mindset of the future BMET can be changed. When realising this mindset change, the first step towards an active work mentality and thus a successful BMET is made. Therefore this research will investigate the possibility to stimulate motivation within an online training.

## 1.2. Research Aim

As described in the problem statement, the large number of out of service medical and laboratory equipment is caused by, among others, a shortage of training available in LMIC and missing motivation among active BMETs [4][5][6]. This research aims to form the first step in the development of a Massive Open Online Course (MOOC) to train Biomedical Equipment Technicians, accessible to everyone free of charge. This MOOC must decrease the shortage of properly educated BMETs in LMIC. The first step towards the development of the MOOC, is the development of a Pilot Course, in which the possibility of a MOOC to train BMETs is investigated. MOOCs of all types have been proved to be effective, however, only a small number of MOOCs are developed for such a practical and context dependent topic. Therefore this Pilot Course must mainly investigate possible effectiveness of a MOOC for this application. So the aim of this research is to prove the possibility to educate BMETs with a MOOC or Pilot Course.

In addition, this research aims to prove intrinsic motivation to succeed, by receiving high grades in an online training or course, can be stimulated. Forming the first step in increasing motivation among BMETs at global scale. Stimulating motivation as described in the problem statement, by implementing a mechanism in which success is recognised, responsibility morally increased and failure connected to social consequences, is not possible in a Pilot Course. Since consequences, both positive and negative, can only be implemented on the work floor or a non-voluntary environment. This research however, is completely voluntary to participate in and will only cover a small part of the final complete content. In addition, the scope of this research is limited to the Pilot Course. Therefore a setup must be created in which the theory behind the proposed solution could be tested. This research will test the possibility to stimulate motivation within training to perform better at the training, by testing if grades received in the Pilot Course increase when stimulating motivation. If this possibility is proven, the next step would be to test the possibility to stimulate intrinsic motivation within training to be a successful BMET and to perform the job as requested. So the possibility to positively influence behaviour and mindset of the BMET. If intrinsic motivation, to be successful as a Biomedical Equipment Technician, could indeed be stimulated during training, the number of out of service medical and laboratory equipment can be decreased significantly at global scale.

## 1.3. Research Questions

The following research question has been formulated in order to meet these objectives:

*Can the required level of knowledge and set of skills for Biomedical Equipment Technicians be achieved through a Massive Open Online Course?*

This research question will be answered by first analysing the following formulated sub questions:

1. *What is the best setup for a MOOC to train Biomedical Equipment Technicians?*
    a. *What type of exercises are most effective?*
    b. *What should be the duration of the complete course?*
    c. *What should be the entry level of the course?*
2. *Will exposing participants to motivational incentives increase the grades received in the online Pilot Course?*
3. *Will exposing participants to motivational incentives increase the percentage of participants finalizing the Pilot Course?*
4. *Are the results, achieved within this research, influenced by characteristics or qualities of the participants?*

The hypothesis for this research, followed from the research questions, is formulated as follows:

*'Biomedical Equipment Technicians can be educated with the required knowledge level and set of skills through a MOOC, in addition results of participants and completion rate among participants will increase when being exposed to motivational incentives, where no other characteristics influencing results can be found.'*

This research is focused on the possibility to train BMETs via an online course and motivation to perform within that course. The effect and possibility to influence motivation will thus be analysed by measuring the difference in performance among participants exposed to motivational incentives and participants not exposed. In addition trends and links between characteristics of participants – cultural effects, rural/urban surrounding, prior experience – and the effect of these characteristics will be analysed. Based on conclusions found, a recommendation for the design of an online BMET training will be given.

## 1.4. Research Scope

In order to find the answers to the questions we formulated above, a Pilot Course was developed. The Pilot Course will be completed by a group of volunteers in which variables are tested and results measured. Based on these results, a recommendation for the design and setup of a Massive Open Online Course (MOOC) to train potential Biomedical Equipment Technicians, applied to Low-/ Middle-Income Countries, can be given. Also, a conclusion can be formed whether intrinsic motivation can indeed be stimulated in training phase. The scope of this research is limited to the Pilot Course and its results.

Let us elaborate further on the scope of this research applied to the research questions. First of all, the possibility to educate BMETs with the required knowledge and set of scales. This will be tested by analysing results, where results will be based on surveys included in the Pilot Course, on performance and on improvement made by participants throughout the Pilot Course. The improvement will be measured by comparing results of an initial knowledge quiz and a final assessment. Performance is measured by calculating the Total Grade of participants.

Secondly, the possibility to stimulate motivation to perform within training. As explained earlier, this research does not enable testing the possibility to motivate participants in training phase to perform better whilst working as a BMET. Since the scope of this research is limited to the Pilot Course. Therefore this research will analyse the possibility to stimulate motivation to perform better within the Pilot Course. If it can be proven that stimulating motivation to perform better within the Pilot Course is possible, the first step in proving the possibility to stimulate motivation to perform as BMET, via an online training or MOOC, is set.

This research is limited to people volunteering to participate; together with the Nick Simons Institute, the Infratech platform and the Technical University of Delft and its network, a group of participants was created. Results are based on the results of the Pilot Course, including surveys, of that specific group of participants only.

This research is focused on developing countries also called Low-/ Middle- Income Countries, LMIC. According to the United Nations, there is no uniform definition for the designation of the convention of a country or nation being underdeveloped or a LMIC [9]. However, to clarify terms, the United Nations has included certain factors relevant for the indication whether a country is developed, in transition or developing. These factors and their influence are constantly changing. Combining these factors gives the following definition of development, according to the United Nations; "*Development is a multidimensional undertaking to achieve a higher quality of life for all people. Economic development, social development and environmental protection are interdependent and mutually reinforcing components of sustainable development"* [10]. Reasoning for the direction towards LMIC is the large improvement needed and possible in these areas, as explained earlier in this chapter.

## 1.5. Thesis Setup

In Chapter 2, a background information study is performed, analysing different forms of motivation, the role of motivation within learning methods, cultural differences and effects on motivation and the current missing motivation among BMETs. A visualization of the research design of this complete research is presented in Figure 1.1.

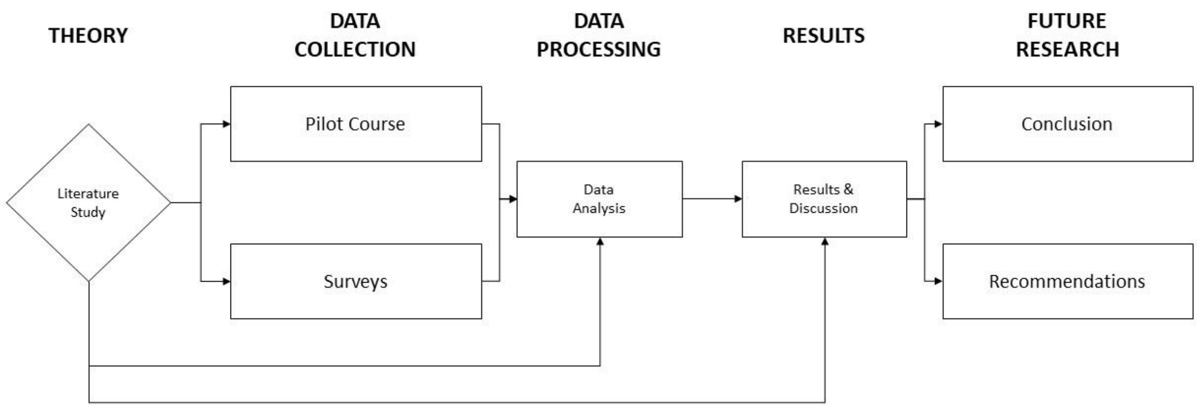



FIG. 1.1 Visualization of the research design.

The data are collected by running a Pilot Course, where performance and improvement made by participants are measured. This measurement is done by comparing results of an initial knowledge quiz and a final assessment. In addition, all participants of the Pilot Course were requested to fill in a number of surveys. Chapter 3 elaborates on this data collection process.

The results of this research are given in Chapter 4.

The collected data are processed by performing statistical analyses, this analysis and interpretations of the results are elaborated on in Chapter 5. Data are mainly analysed by performing descriptive statistics, but verified with statistical tests.

Lastly, Chapter 6 elaborates on conclusions and recommendations arising from the results found.

# 2

# Theoretical Background

This chapter aims to provide the theoretical background of the study. It is based on the literature review: 'Motivation for Biomedical Equipment Technician Training in Low-/ Middle- Income Countries[1]' [11]. Topics most relevant for this research study are summarized in this section. First of all, this chapter elaborates on motivation; definitions from literature, different types and phases of motivation and cultural differences. Secondly, three learning models applicable to this application will be summarized. Lastly, the current situation of BMETs and health care in LMIC is clarified. For a more elaborated literature study, please refer to Appendix A.

## 3.1. Motivation

Motivation is defined as 'the will to do something' [9]. Within training, motivation is a very important factor, both to start and to complete the training successfully. Motivation is of relevance to this research, since many medical and laboratory equipment reported as out of service could easily be repaired by currently active BMETs in LMIC, however due to lack of motivation and due to frustration, this is not being done [4]. Therefore analysing motivation and searching for manners to stimulate intrinsic motivation among BMETs after completion of an online training, could improve the existing issue.

### 2.1.A Types of Motivation

P. K. Murphy and P. A. Alexander created an overview of all terms and definitions used within literature to explain motivation, in their article; "A Motivated Exploration of Motivation Terminology". The overview of all definitions and terms can be found below in Figure 2.1.

[1] This report has already been graded and ECTs have already been assigned. The review was initially written to fulfil my Literature Study, a compulsory element of the complete graduation. A summary of the study has been given here to provide a complete research, including the literature study performed prior to this thesis project. This chapter provides a brief summary and link towards this research, whereas Appendix A provides a more extended summary of the literature review as it was composed originally.

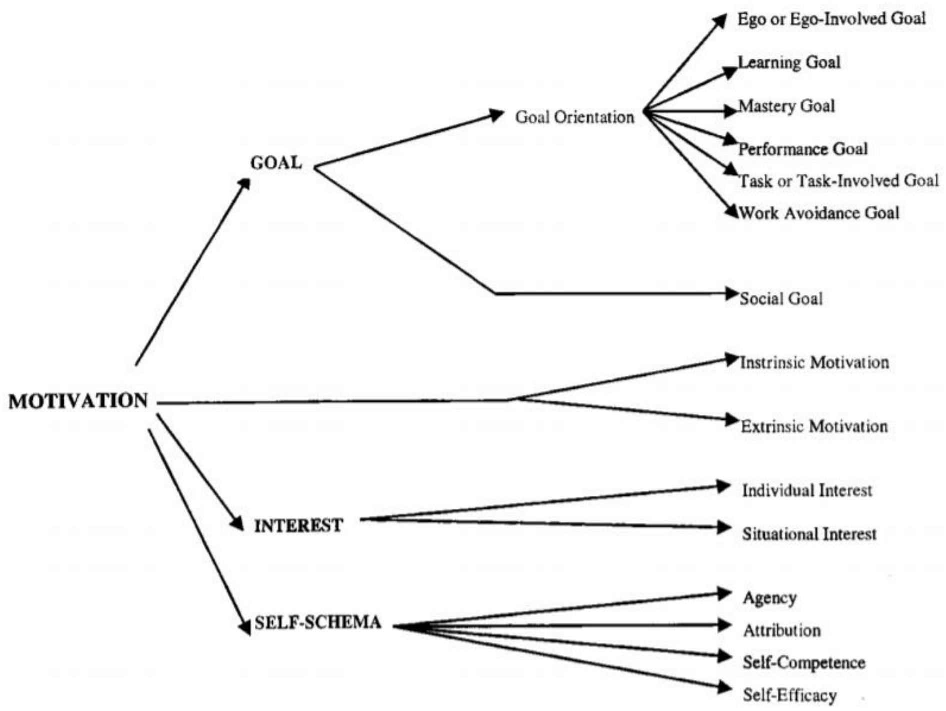



FIG. 2.1 The resulting corpus of 20 motivational terms relevant to academic achievement and motivation [12].

The terms within Figure 2.1 were defined based on literature studies focused on the construct of academic achievement or academic development. The aim of P. K. Murphy and P. A. Alexander was to create a theoretical overview, purely based on literature and proven theory [10]. Four types or differentiations were defined. First of all; goal orientated motivation is defined as 'a set of behavioural intentions that determine how students approach and engage in learning activities'. This definition is based on the definition of a goal by Wentzel: 'What students generally want to achieve in their classes be it academic or social' [13].

Second of all, intrinsic versus extrinsic motivation. Intrinsic motivation is defined as 'the internal drive to engage or perform' [12][14]. In other words, intrinsic motivation is a drive from within, not caused by external factors. In contrary, extrinsic motivation is defined as 'motivation from rewards given for appropriate behaviour' [14]. So extrinsic motivation is caused by external factors, often encouraged by financial rewards.

Thirdly, motivation driven by interest, where interest is defined as the underlying needs and desires by which the process of learning is energized [15]. Motivation driven by interest is motivation stimulated by a certain interest.

Lastly, Motivation through Self-Schema; Self-Schema is defined as self-knowledge, mainly referring to individual differences in perceiving and responding to events. Self-Schema motivation refers to a self-chosen manner to learn and develop, based on proper self-knowledge.

Whilst analysing the above described types of motivation, intrinsic motivation is the most relevant type for this application. If it would be possible to intrinsically motivate BMETs to become successful within their role and make them aware of the importance of their job, external effects matter less. Meaning that the limitations present in LMIC are considered less as obstacles to perform their job successfully.

### 2.1.B The different Phases within Motivation

A research by Chen, Warden and Chang, investigated motivation in language learning. In their research they defined three phases of motivation, with different incentives per phase. The first phase, the Preactional Phase, is the phase prior to action, in which motivation must be initiated. The second phase is the actional phase in which motivation must lead to action. The last phase is the Postactional Phase, this is the critical retrospective phase after the action has completed [16]. The overview is visible in Figure 2.2 below.

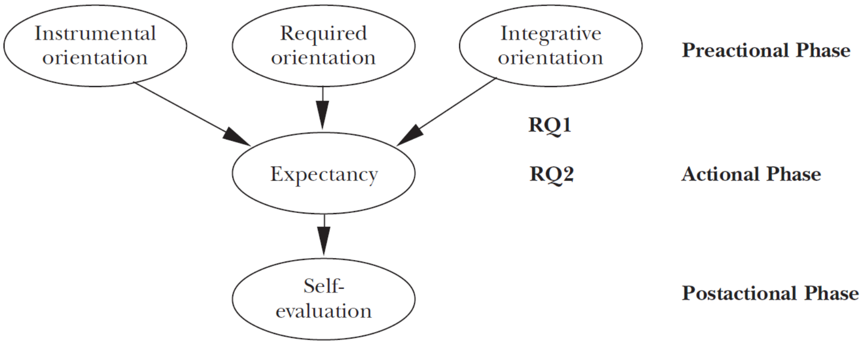



FIG. 2.2 Different phases of motivation in language learning for settings where English is a Foreign Language (EFL) [16].

Analysing the above visualized phases, motivation must be stimulated to perform successfully as BMET in the postactional phase. This motivation must be stimulated in the actional phase, so ideally phases would overlap or influence each other. Since that would be the only manner to improve the existing problem of demotivated and frustrated BMETs at global scale, by stimulating intrinsic motivation within training. However, the scope of this research is limited to the Pilot Course, so to the actional phase only. Therefore this research will investigate the possibility to stimulate intrinsic motivation to increase grades received for the Pilot Course, so stimulate motivation in the actional phase to perform better in the actional phase. If this research proves that possibility, the next step will be to stimulate intrinsic motivation in the actional phase, leading to better performance in the postactional phase.

### 2.1.C The Effect of Culture and Cultural Differences on Motivation

When understanding motives of individuals, it is important to acknowledge and understand one's norms and values and thus his or her culture. Hofstede came up with a very useful dimensional definition of culture. In his theory he separated culture in five dimensions, leading to variating cultural values; (1) hierarchy, (2) identity, (3) gender, (4) uncertainty and (5) orientation. In addition to the five-dimensional definition, Hofstede states culture effects nonverbal behaviour as well. Part of the identity dimension for example is the expression of emotion and whether this is acceptable among a culture or not. In the United States it is acceptable to express negative emotions like fear, anger or grief, whereas in a collectivistic culture like Japan this is not accepted.

Analysing the distinction made by Hofstede, one must consider LMIC and their cultural values and norms whilst designing and online training and whilst grading performance within an online training. Appendix A gives a more elaborated description of the distinctions made by Hofstede. When designing this Pilot Course, cultural norms and values of LMIC, Nepal specifically, were taken into consideration. Results will be analysed to verify if the design was setup correctly, whilst considering these cultural differences.

## 3.2. Learning Models

In literature, several different learning models can be identified. A selection of those models found in literature and judged on most relevant for this application are summarized below. The selection is based on the context of LMIC, the final appliance of this research, the importance and relevance of motivation within the model and the possibility to apply suggested methods.

The first model is based on the theory that the learning strategy used is based on motivation. This theory originally came from Biggs. He defined three links between learning strategy used and motivation. The first link is based on instrumental motivation, so based on extrinsic, instrumental rewards when successful in studying or performing tasks. The strategy linked to this motive, utilising, is in general mainly focussed on avoidance of failure. More specifically this means limiting effort, superficial fact learning, based on passing tests and exams rather than deeply understanding the matter [17]. The second link, where intrinsic motivation is leading, is formed from the desire within to develop abilities and special interests. The strategy chosen is internalising. The subject is made personally meaningful to the student by studying according to this strategy [17]. The last link is the link between motivation driven by achievement, coupled to the strategy referred to as achieving as well. An achieving motive is recognized by the urge to win and excel, so to fulfil a competitive approach to life and to excel in what you do. The achieving strategy linked to this motive is a diligent attitude, a structured working schedule and a hard working mindset [17].

The second learning model is based on a review of Janet Metcalfe and Nate Kornell. The model referring to is the 'Region of Proximal Learning model'. The model is based on the theory that learning is led by expectation and self-efficacy. When starting, the student will eliminate all known items or subjects. Subsequently the student will prioritise the unknown items based on assumed level of difficulty, where one will study the remaining subjects in rang order, from assumed easy to difficult. Whilst studying, the student must decide when to quit an item and continue to the next item or continue with further studying, this is done based on the self-judgement of progress. So, according to the model, the student will continue as long as he or she is perceiving himself to be learning. The student will stop and continue to the next item when learning is no longer paying off and progress has stopped [18].

The last model is based on a study by Henry L. Roediger III and Andrew C. Butler, which showed the importance of practice. They developed a learning model in which practice is implemented and fulfils an important role. According to Roediger and Butler, practice has a positive impact on long term retention and functions as a very powerful mnemonic enhancer [19]. A second benefit according to their research is that practice provides flexibility in retrieval of information and thus enables the student to use gained knowledge in different settings and contexts as well. The mnemonic enhancers help to produce more than only a simple response, it helps in understanding the underlying theory and thus to translate the knowledge to different contexts [19].

The Pilot Course used for this research is setup whilst considering learnings from the last model, so practice is implemented accordingly. The second model is not implemented, since the model relies on the ability of self-efficacy. If participants are not capable to judge their own knowledge and capabilities accurately, the training will not be successful. The possibility to stimulate intrinsic motivation which is investigated by this research relies on the first model, which states intrinsic motivation leads to a desired learning method.

## 3.3. Current Situation

In the current state of affairs, it is clear we are getting things wrong. Equipment is not being used, due to small or large technical errors or due to misunderstanding of how to use the equipment. However, the equipment is very much needed. Local populations have already done many attempts in order to improve the current situation in differentiating manners and forms [20]. Some have been beneficial and effective, however there are still many improvements required. The most relevant lesson from the several attempts is that local context and cultures must be valued and considered. Implementing Western systems or systems based on Western values have proven to be ineffective. Hierarchy and communications towards and around BMETs existing in LMIC does not give them incentives to be successful. The current existing lack of incentives is partly due to the implemented Western and Euro-American way of communicating and rewarding within hospitals and towards BMETs. In order to give BMETs in LMIC incentives to be successful one must identify and recognize their cultures and drivers towards success. Numerous practicalities in order to live out these drivers can be implemented, but the important point here is that motivation is the key word and in order to effectively stimulate people one must understand, respect and apply their values, not ours. Implementing a mechanism in which their success is recognised, responsibility morally increased and failure connected to social consequences, will have serious impact on motivation in collectivistic cultures and thus success rate [33]. However, such a mechanism attacks the issue at local scale, ideally a solution would be found to solve the issue at global scale. A possible solution could be to stimulate motivation in training phase. If then a MOOC would be developed, free of charge and accessible to all, the issue would be solved or at least improved at global scale. However, it has never been proved that motivation can be stimulated in training phase. Therefore this research will set the first step in stimulating motivation among BMETs, by analysing whether motivation can be stimulated in training phase resulting in better performance within that same training. If so, the next step would be to analyse if motivation, stimulated in training phase, can result in better performance after that training.

# 3

# Research Methodology

This chapter elaborates on the methodology that is used to setup this research. Furthermore, on the methodology used to collect data on the possibility to train BMETs via an online platform and the impact of stimulating intrinsic motivation applied to online training of Biomedical Equipment Technicians in Low-/ Middle- Income Countries.

## 3.1. Pilot Course

In order to answer the main and sub questions, a Pilot Course was developed. The main goal of this research was to verify whether Biomedical Equipment Technicians can be educated with the required set of skills and knowledge via an online training and what the best setup of that training would be. Additionally, this research investigated whether intrinsic motivation can be stimulated in training phase to perform better in an online training. Answers to these questions were sought by setting up a Pilot Course. A Pilot Course, a mimicry of the end goal; a MOOC to train BMETs, was created in which different setups, hypothesis and scenarios could be tested. In addition a Pilot Course provides an agile form of verification. Setting up a complete MOOC is time and effort consuming and does not allow for micro analyses, or at least less than a Pilot Course. The Pilot Course will be completed by a group of volunteers in which variables are tested and results measured. Based on these results, a recommendation for the design and setup of a final MOOC, to educate BMETs, can be given. Also a conclusion can be formed weather intrinsic motivation can indeed be stimulated in training phase.

### 3.1.A Design and Content

As explained, a Pilot Course was developed to verify the hypothesis of this research. The design and content of the Pilot Course is based on the design and content of the MOOC to be developed, to train Biomedical Equipment Technicians in LMIC. The Pilot Course will be setup as a small part of the MOOC. This section will elaborate on the design and setup of both the Pilot Course and the final MOOC.

#### 3.1.A.1 Design and Content MOOC

The MOOC to train BMETs in LMIC, will be a complete online training, existing of three courses; (1) Course 1 ‘Basics of Biomedical Equipment Maintenance for BMETs’, (2) Course 2 ‘Maintenance and repair of biomedical equipment’ and an optional third course, (3) Course 3 ‘Train the trainers of BMETs’. The third course will be a follow up course on course 1 and 2 and is aimed for BMETs who have successfully finalized the first two courses. The Pilot Course developed in order to test the hypothesis and find answers to the research questions is based on Course 2 of the design of the MOOC. Therefore Course 2 will be elaborated on further in this section, for more information on the design and setup of the other Courses, please refer to Appendix B.

Course 2 'Maintenance and repair of biomedical equipment' is setup to give learners the ability to diagnose and repair common problems on medical equipment within hospitals in LMIC. The course exists of six modules; (1) Module 1: General engineering skills and good practices, (2) Module 2: Maintenance/diagnosis/repair of Diagnostic medical equipment (e.g. pulse oximeters, patient monitors) in low resource settings (for each core equipment), this module will cover preventive maintenance, troubleshooting/diagnosis, repair and testing of core equipment within this category. The following modules will cover the same topics for core equipment within its category; (3) Module 3: Maintenance/diagnosis/repair of therapeutic medical equipment (e.g.: life support equipment, surgical equipment, electrosurgical equipment, etc ) in low resource settings (for each core equipment), (4) Module 4: Maintenance/diagnosis/repair of analytical medical equipment (e.g.: laboratory equipment, etc) in low resource settings (for each core equipment) and (5) Module 5: Corrective maintenance/diagnosis/repair of Miscellaneous equipment (e.g.: sterilization equipment, medical waste management) in low resource settings (for each core equipment). The last module (6) Module 6: Supporting topics, will again cover supporting topics, so will educate learners on general knowledge, the way of working and how to find information. This module is a duplicate from Module 4, Course 1.

The complete course is still in design phase and definite setup and content are dependent on the outcomes and learnings of this research. However, when setting up the Pilot Course, this was the design and setup for the final MOOC, so the design and content of the Pilot Course is based on the above explained content. A more detailed elaboration on the content of the complete MOOC can be found in Appendix B.

#### 3.1.A.2 Design and Content Pilot Course

As explained before, the Pilot Course developed for this research is a short-limited version of the final MOOC. The main focus of the Pilot Course will be on one selected device in order to test the hypothesis, training techniques and methods used. By selecting one device only, the time needed for participants to complete the Pilot Course can be minimized and variables bounded. The selected device is the Patient Monitor. It will include the Central Station of the device and the Monitor with Physiological Elements. This device is selected since it is included as part of the Core Medical Equipment by the World Health Organization (WHO). The technical terms assigned by the WHO are: "Monitor, Central Station" and "Monitoring System, Physiologic". Another reason for selecting the Patient Monitor is the variation and complexity within and of the device. Since the monitor consists of a central station and measures several physiological symptoms of the human body, the required knowledge and capabilities are very varied. This enables a varied setup and content for a Pilot Course. When testing a simpler device, existing of less complex and varied parts and functions, it might not be possible to test all learning methods or the exit level might not be sufficient to test the hypothesis.

The Pilot Course will exist of (1) an introduction to the course, two modules covering relevant topics concerning the Patient Monitor; (2) Module 1: General Biomedical Engineering Skills, (3) Module 2: Diagnostic Medical Equipment, a final assessment and a course closing. The setup of the content is based on a storyboard and blueprint, which can be found in Appendix C. A schematic overview of the Pilot Course can be found below:

- Introduction to the Pilot Course
    - Welcome!
    - Why become a Biomedical Equipment Technician
    - Outline of the course
    - Introduce yourself!
    - Pre-Survey
    - Initial Knowledge Quiz
- Module 1: General Biomedical Engineering Skills
    - Anatomy and Physiology
- Module 2: Diagnostic Medical Equipment
    - Patient Monitor.I – Device and Components
    - Patient Monitor.II – Preventive Maintenance
    - Patient Monitor.III – Troubleshooting
    - Patient Monitor.IV – Repair
    - Patient Monitor.V – Testing
- Final Assessment
- End of the Pilot Course
    - Feedback on the Course

The introduction, 'Introduction to the Pilot Course', is meant to introduce participants to the course, the instructors and the profession of becoming a Biomedical Equipment Technician. In addition, the introduction will request pre knowledge and background information from participants, which is needed for research purposes. The introduction must involve participants in the course and give a personal aspect.

The introduction starts by welcoming the participants to the Pilot Course, by giving explanation of this research and thanking them for their participation. This is followed by an introduction video of the lecturers, shown in Figure 3.1 below. This video must personally involve participants into the Pilot Course. Lastly, some recommendations and explanations are given on technical and practical aspects of the course.

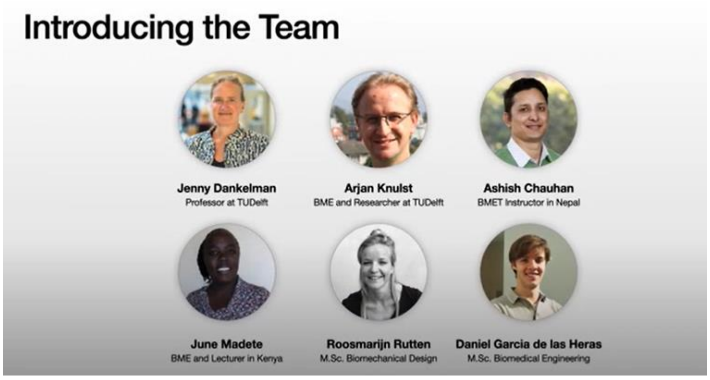


FIG. 3.1 Video to introduce the team behind the Pilot Course, inserted in the introduction of the course.

After the welcoming messages, the introduction will elaborate on why to become a Biomedical Equipment Technician. This section is implemented in order to answer the research question and should stimulate intrinsic motivation. More detail on the content of this section and how this section will help to answer the research question, will follow in the next sub chapter.

Subsequently the outline of the course is explained, to manage expectations of participants. This is important since motivation and thus completion rate, is partly based on expectations [16][18].

The section 'Introduce Yourself!' requires participants to introduce themselves to their peers in the discussion board. This must increase interaction between students and allow them to exchange knowledge, cooperate and both request and provide help.

Lastly, the Pre-Survey and the Knowledge Quiz are implemented to gather information on the participants for research purposes. The Pre-Survey requests participants' information on prior knowledge, age, location and expectations of the course. The Knowledge Quiz is an assessment to measure knowledge on the application prior to the Pilot Course, in order to measure the improvement made by participants. This will be used to analyse results.

'Module 1: General Biomedical Engineering Skills', elaborates on the anatomy and physiology knowledge needed to understand the Patient Monitor. After a brief introduction, five physiological topics are discussed; (1) The Cardiovascular System, (2) The Heart and Electrocardiography ECG, (3) Blood Vessels and Blood Pressure, (4) The Respiratory System and last (5) Body Temperature. These physiological elements are required to understand in order to operate the Patient Monitor. In addition, adding physiological elements enables experimenting with different methods to teach theoretical knowledge, where the other elements of the course require more practical understanding. Module 1 is ended with a closing section.

'Module 2: Diagnostic Medical Equipment' exists of five sections all elaborating on the Patient Monitor; (1) Device and Components, (2) Preventive Maintenance, (3) Troubleshooting, (4) Repair and (5) Testing. This section must educate the learner with technical knowledge and capabilities on the Patient Monitor. The first section educates the learner with an understanding of the device itself, the other sections of the Pilot Course educates learners with the tasks belonging to the responsibilities of a BMET. That is the reasoning behind this content and setup.

The first section 'Device and Components' will initiate with an introduction on the Patient Monitor, showing the device in general, its components and the working mechanisms. Next, the system block diagram is explained, to educate participants on the technical working mechanism of the Patient Monitor. Before ending this section, four technical components of the Patient Monitor are explained; (1) ECG and Respiration Monitoring, (2) Pulse Oximetry Monitoring, (3) Non-Invasive Blood Pressure Monitoring and last (4) Temperature Monitoring. After this section the participants must understand the function and working mechanisms of the Patient Monitor.

The other four sections all elaborate on capabilities expected from a Biomedical Equipment Technician, applied to the Patient Monitor; Preventive Maintenance, Troubleshooting, Repair and Testing. In the section Preventive Maintenance, participants are requested to create a preventive maintenance checklist for the Patient Monitor. They have to share their personal checklist in a discussion form with fellow peers and thereby share information and help each other with remaining questions and knowledge gaps. This teaching technique creates an interactive learning environment and forces participants to connect with fellow peers. Afterwards a correct checklist is given, so that the created checklist can be corrected. Since it is important in the learning process that participants are exposed to the correct knowledge. In the third section; Troubleshooting, common errors are elaborated on and explained how to be detected. In the section 'Repair' the course explains how to dissemble the Patient Monitor, this is done by text, photos and video, to visualise and thereby mimic real-life lessons. The last section, Testing, explains by video how to perform tests on the Patient Monitor, to verify if the Monitor is working as desired.

Throughout the course, different setup and methods are used. The physiology and device and components sections have a more consistent setup, since these are used for a different research[2]. The research referring to specifically tests the impact of interactive versus not interactive content and must therefore maintain a more consistent setup. The sections preventive maintenance, troubleshooting, repair and testing all have a different setup. Preventive maintenance requires, as described, interactive learning of the participants. In addition this section requires participants to interact with each other and to self-evaluate their work. Theory explaining preventive maintenance, was given only after the exercise was completed. In troubleshooting, participants were first exposed to theory and had to complete assignments afterwards. This variation in assignment timing was done to have a variated course setup and to test different teaching strategies and manners.

The Final Assessment assesses participants on all knowledge and capabilities discussed in the Pilot Course. This is done with a number of different exercises. The Final Assessment is used to answer the research question and as a data set within this research. The reason for creating different assignment types is to enable the possibility to give a substantiated advice on what manner of questioning is both effective and appreciated by participants. In addition technicalities of different question formats can be tested in this way.

The final section; 'End of the Pilot Course', expresses gratitude to the participants for their participation and requests them to fill in a feedback form. Responses will be used to improve the design and setup of this course and to gather background information and relevant experience insights.

A more detailed description and visualization of the Pilot Course can be found in Appendix D, where images and more detailed explanations on the content are given.

### 3.1.B Platform

The Pilot Course has been created in edX Edge, a platform of edX. EdX is a platform founded by a collaboration between Harvard and MIT and setup for online education and learning. EdX has grown to a large platform home to over 20 million learners, of whom most work at industry-leading companies or top ranked universities. The platform aims to transform traditional education to online education, removing barriers like cost, accessibility and location. In addition, education on edX allows students to learn at their own pace and whenever available in contrary to traditional education with set locations, lecture hours and costs. EdX is a non-profit organisation collaborating with many top ranked universities to provide education at all levels and professions.

The Technical University of Delft also has a collaboration contract with edX, therefore the final MOOC and thus also this Pilot Course, was created within edX. The reason for choosing edX Edge over edX, is that edX Edge is a platform reserved for small private online courses, in contrary to the public

[2] Research performed by Daniel Garcia de las Heras; 'Fundamentals for the Design of a MOOC to train Biomedical Equipment Technicians in LMIC'.

and open platform edX. EdX Edge allowed this research to test features and thus run the Pilot Course in a controlled environment, rather than on an open public page. This therefore allowed for more participant specific insights and control.

### 3.1.C Teaching Methods and Grading

Throughout the course, several different teaching methods were used. Reasoning for this variation was threefold; first of all variation is stated to improve both motivation of participants and their results. Secondly, by using various techniques a more extended recommendation for the design and setup of the final MOOC can be given based on the effectiveness within the Pilot Course. Lastly, a second research is running on this Pilot Course, evaluating the effect of 'interactive learning' on the results of participants[3].

Four methods to educate learners with theoretical knowledge were used; (1) textual description, (2) explanatory photos, (3) instructional- or explanatory videos and (4) self-learning, meaning participants had to try to find or come up with the information themselves. Self-learning was done with exercises where correction was performed in two different manners; self-evaluation and peer evaluation. Self-evaluation was done by providing the student with the correct answers. Peer evaluation was executed by requesting learners to post their answers on a discussion board, where they could discuss with and react to fellow peers, who had also uploaded their answers.

Practice or testing of knowledge was done in two different manners; with multiple choice and open questions. Within multiple choice, the Pilot Course made use of five different types of multiple-choice questions; (1) regular multiple choice, (2) dropdown multiple choice, (3) checkboxes, (4) drag and drop exercises and (5) true or false questions. The benefit of dropdown questions is that participants will not immediately be exposed to the answers, forcing them to think about the question first, contrary to regular multiple choice. In regular multiple-choice people tend to be led by the answers rather than the question. Checkboxes increases the level of difficulty compared to both regular multiple choice and dropdown questions, since the correct-guess probability decreases. Learners do not know how many answers should be selected, opposed to only one in regular multiple choice. In addition learners might get confused by the larger number of possible answers. Drag and drop does guide the learner to the amount of answers sought, however answers are easily swapped, automatically leading to two mistakes instead of one. True and False has the highest correct-guess probability, decreasing the difficulty level. However True and False questions tend to be very confusing and often require very secure reading.

Open question occurring in the Pilot Course where either computer evaluated, or as mentioned before, self- or peer evaluated. Computer evaluation decreases fraudulent corrections, however spelling or capital letter mistakes are often not detected by the computer.

The Pilot Course contained nine sections with questions; (1) Introduce yourself, (2) the Pre-survey, (3) the Knowledge Quiz, (4) Physiology Activities, (5) PM.I Device and Components, (6) PM.II Preventive Maintenance, (7) PM.III Troubleshooting, (8) the Final Assessment and (9) the Feedback Survey. The table below, Table 3.1, illustrates the amount of questions per section and the rating allocated to that section and thus all questions corresponding.

[3] Research performed by Daniel Garcia de las Heras; 'Fundamentals for the Design of a MOOC to train Biomedical Equipment Technicians in LMIC'.

| Section | Amount of Questions | Rating |
|---|---|---|
| Introduce yourself | 1 | 1% |
| Pre-Survey | 1 | 2% |
| Knowledge Quiz | 13 | 5% |
| Physiology Activities | 9 | 10% |
| PM.I Device and Components | 8 | 10% |
| PM.II Preventive Maintenance | 1 | 10% |
| PM.III Troubleshooting | 4 | 10% |
| Final Assessment | 24 | 50% |
| Feedback Survey | 1 | 2% |
| *Total* | *62* | *100%* |

TABLE 3.1 Grading of the Pilot Course

There is not a specific reason for the amount of questions in the different sections, leading was the amount of time needed to complete a section and the abilities in edX. Sections with only 1 question, contained a more extended exercise or several additional questions, hidden in a different platform. Both surveys contained additional questions, but they had to be completed via an external link to Google Forms so are not visible in this overview. Reasoning for using Google Form to complete the survey and for using an external link to expose the surveys, is to reach maximum clarity among participants and to ease analyses. Analyses of results can easier be done via Google Forms with this type of questions and data can better be allocated to specific participants. With regards to clarity; the next button within edX can easily be confused with the next button of the survey. If that confusion would occur, this would result in an incomplete survey response. Therefore, based on recommendation and experience of the edX support team, the survey had to be completed via an external link.

The section Introduce Yourself and Preventive Maintenance required participants to post content in the discussion board, which thereby equals a more extended question as well. Therefore the sections are limited to one question only. The difference in the amount of questions of the Knowledge Quiz compared to the Final Assessment can be explained by the main goal of both assessments. The Knowledge Quiz is implemented to give an indication of prior knowledge, so requires less detailed results. Whereas the Final Assessment is meant to test acquired knowledge of different sections and therefore required a more detailed and accurate result. The amount of questions for the other sections was led by the amount of time and effort needed to complete the questions and the possibilities within the edX platform.

From the questions illustrated in Table 3.1, some could only be responded with yes or no and could thus not be graded on quality of the response. The reasoning for allocating a percentage to these questions is to add an incentive for participants to complete these parts. So adding a grade to these parts aims to make those sections compulsory. The sections I am referring to are; (1) Introduce Yourself, (2) Pre-Survey, (3) PM.II Preventive Maintenance and (4) Feedback Survey. In these sections participants had to either fill in a survey via a link or post something in the discussion board. The only manner to check whether participants indeed performed what was requested, was by adding the question 'Did you complete the survey?' or 'Did you post in the discussion board?'. However, since these questions could not verify quality of the response, a relatively low rating was allocated.

Furthermore, rating is based on importance of the different sections. Least important is the 'Introduce Yourself' section, participation is desired to make the course interactive and to encourage collaboration between participants. However this is a nice to have rather than a must have, for that reason this section only counts for 1%. Next, both surveys are not relevant to the learning progress of participants, but are important to this research. Therefore a rating is given to make the surveys compulsory, as explained before, however a heavy rating would influence results. Same could be said about the Knowledge Quiz, however this is concerning the content of the course and of even higher relevance to this research, therefore this is rated slightly heavier. Next, the actual content of the course; all exercises are expected to be completed by participants as learning mechanism. Each separate section is equally important, therefore equal rating is allocated. The Final Assessment is the most important section of this Pilot Course. The Final Assessment is relevant for this research, but also an important contribution to the content and learning process of the participants, therefore the highest rating percentage is allocated to this section.

## 3.2. Implementation Research Question

In order to answer the research questions a section was added to the Pilot Course, referred to as 'Why Become a Biomedical Equipment Technician'. This section was only accessible to half of the participants invited to participate in this Pilot Course, providing the possibility to measure the impact of the section on the results of the participants. This section will elaborate on the creation and content of the video and the execution within the Pilot Course.

### 3.2.A Study Setup

As explained in the introduction, substantiated by the background study; lack of motivation is, among others, causing the large number of medical and laboratory equipment being reported as out of service in Low-/ Middle- Income Countries. Present BMETs are not motivated to perform preventive maintenance on regular basis, neither to perform repairs needed. Reasoning for lack of motivation, apart from practical reasoning, is threefold; (1) frustration on the hierarchy within the hospital, (2) missing job description and (3) missing consequences of failure and missing rewards for success [4][6]. This research will form the first step in investigating if lack of motivation among BMETs can be improved by exposing participants to motivational incentives during training and thereby decrease the issue at global scale. Analysing the direct effect and possibility is beyond the scope of this research, since the scope is limited to a Pilot Course. So measuring the impact of motivational incentives on productivity and motivation of BMETs on the job exceeds the scope of this research. However, this research aims to prove whether motivation can be stimulated during training at all. If so, the next step will be to prove motivation stimulated during training has effect on the productivity of BMETs on the job and thereby decreases the number of out of service medical and laboratory equipment.

When investigating how to realize above mentioned goals, focus is positioned on Nepal. Reasoning for this focus is the collaboration with the Nick Simons Institute in Nepal and thus the large network available. So the motivational incentives could be designed for that specific culture to maximize the impact.

In Nepal motivation is strengthened by recognition. In the culture of Nepal, similar to the culture of India where the caste system is still active, recognition and preventing loss of face are extremely important to people and could thus function as motivational incentives [7][8]. Therefore a motivational incentive needs to be setup to show participants, following the Pilot Course, that recognition will be received when working as a successful BMET. In addition a clear job description must be provided, a current problem reported by Nepalese BMETs is lack of clarity of responsibilities and tasks. Currently 72% of graduated BMETs of the Nick Simons Institute (NSI) training state having unsupportive colleagues and almost half of the employed BMETs report not having a job description [21].

#### 3.2.A.1 Considerations Motivational Incentives Setup

In the development of motivational incentives, several setups where considered all based on cultural norms and values of mainly Nepal; (1) offering rewards, (2) exposing participants to inspirational content, (3) threatening with consequences of underperformance. Within these three categories, several different forms were explored. All considerations are summarized in Table 3.2 below.

| **Offering Rewards**<br>*when achieving above a certain threshold or when performing best of all participants* | **Threatening with consequences of underperformance**<br>*when achieving below a certain threshold or when performing worst of all participants* | **Exposing participants to inspirational content** |
|---|---|---|
| Meet and greet with influential manager in the industry | Performance evaluation with manager or training institution | Video of hospital staff explaining the importance of a BMET, the difference a BMET can make and the recognition and increased responsibilities possible |
| Job guarantee in collaboration with NSI | Creation of blacklist, which will be spread among hospitals. Limiting job perspectives after underperformance | Video of a patient explaining how medical equipment has enabled his or her treatment |
| Free access to (additional) training of a recognised institute | Exclusion from other training programs to be developed by NSI or TU Delft. | Video of influential person explaining the importance of a BMET, the difference a BMET can make and the recognition and increased responsibilities possible |
| | | One of the above described with text only |
| | | One of the above described with text and photos |

TABLE 3.2 Possible setups of Motivational Incentives.

Table 3.2 given above illustrates all considered motivational incentives. The ideas described are general setup directions, details were to be worked out after the direction was chosen. The setup was selected mainly based on possibilities within the scope of this research and supplemented with insights from literature. Let us analyse the different possibilities per category.

The first possibility of the category 'offering rewards'; a meet and greet with an influential person, could theoretically work since recognition is a very important motivational driver in the Nepalese culture. However, although the motivational incentive is setup aimed at people from Nepal mainly, the Pilot Course must address other cultures as well. In addition it is beyond the scope of this research to arrange the logistics of such a meet and greet. Therefore it was decided not to continue with this setup.

Similar considerations were taken for the second possibility; job guarantee. A guarantee is always hard to promise, especially since quality of the Pilot Course and possibilities to falsify results was not established yet. In addition, some participants might already have a job, so are less interested in or stimulated by this trigger. And most importantly, participants from other countries and continents might participate, the NSI is not capable of making such promises on global scale. Therefore it was decided not to continue with this setup either.

The last reward, offering free access to training, is implemented to motivate participants. However, this was implemented with a different main goal. This was promised to all participants completing the Pilot Course, independent of results achieved, in order to increase the sample size of this research. Therefore this could not be used as motivational incentive within this research anymore. So in summary offering rewards was decided not to be used as motivational incentive, mainly caused by the limitations of the scope of this research and the uncertainty of the group of participants that would enrol.

The second direction to implement as motivational incentive proposes the exact opposite compared to the first possibility. Instead of offering rewards for participants scoring above a certain threshold or for the best participants, the second possibility proposes to impose consequences to underperformance. So participants scoring under a certain threshold, will face consequences for their underperformance. This must educate them underperformance has consequences, in real life and in training phase. Three different forms of consequences were considered, however it was decided that consequences could not be imposed from voluntarily participating in this research. In addition, quality of the Pilot Course and possibilities to falsify results was not established yet, so consequences might not be in line with actual performance or knowledge and capabilities of the participant. Therefore it was decided not to continue with a negative themed trigger within this research setup.

The last and third setup was less practical, but more emotion led. Minimizing possible limitations caused by the scope of this research. The proposed setup is to motivate and inspire participants by exposing them to inspiring content. The proposed possibilities can be split up into two categories; (1) content and main character in the created material and (2) manner of presenting. Let us initiate to elaborate on the manner of presenting; via video, text, photos or a combination. In the design and validation process feedback received was that participants tend to be more focussed when watching videos and videos are more personal compared to solely text or photos. Therefore it was decided to create a video, to maximize the impact of the video and to touch the participants with the message told within the video. The decision for the content of the video was made in collaboration with the Nick Simons Institute. NSI stated an influential person might not address all participants, since participants have variating backgrounds, experience and professions [8]. It was decided to continue with the first proposed possibility, a video of a successful BMET and his manager. Motivation in Nepal is stimulated by recognition, and so for instance a hospital patient would not be able to convince potential BMETs that recognition is given to BMETs when performing well. In addition, recognition from a higher ranked staff member, the manager of a BMET, has more value than recognition from a patient [7][8][21].

Combining all considerations and limitations, it was decided to create a video of a successful BMET and his manager elaborating on the recognition and increased responsibilities he receives when being successful on the job.

In addition to the motivational incentives, a job description was added. Since apart from lack of motivation, lack of clarity on responsibilities and tasks currently causes underperformance of BMETs. Setup of the job description was decided to be clear and simple, to maximize clarity and minimize confusions or distractions. Therefore it was decided to give the job description as textual content.

In this research it was decided to limit the motivational incentives presented to the participants to the above two described incentives, which will only be shown at the beginning of the Pilot Course. Ideally a more repetitive and logical setup would be implemented, where the job description and motivational incentive were elaborated on in great detail at a more logical module within the course. With regards to the final MOOC, the most logical timing would be in Module 1, where the role and responsibilities from a BMET are explained. In addition, repetition ideally would be added to strengthen the effect. However, within the scope and capabilities of this research it was decided to limit the setup to just the above described incentives and setup. Reasoning was the possibility to create content; due to Covid-19 possibilities were limited, in addition our network was limited to the NSI, since cooperation from Africa did not manage to be launched within the set timeframe and deadlines. Therefore it was decided to invest all recourses on one motivational incentive, instead of a variety throughout the course. Lastly, the main focus of this research was the creation of a Pilot Course to investigate the possibility to train BMETs via an online training. So all time and effort were devoted to that goal.

In order to create an ideal setup for motivational incentives extended research must be performed. Hereby techniques taught in persuasive technology classes, created by Stanford University, must be implemented. This class teaches how to coerce people into compulsively using technology and forms the basis for business models in Silicon Valley on psychological manipulation and addiction engineering for Social Media platforms. Implementing similar techniques could impact behaviour and influence the mindset of participants, which will be beneficial in eliminating the discussed issue of lack of motivation among BMETs in LMIC.

#### 3.2.A.2 Motivational Incentives Design

Together with the Nick Simons Institute a video was created. A video in which a successful BMET explains his tasks, the recognition he receives and the increased responsibilities after a period of hard and successful work. To strengthen his message, his manager within the hospital will state similar messages about the BMET and emphasize how much he values his presence and work. The BMET selected for the video is Uttam Pokhrel, working in the Jiri Hospital in Dolakha, Nepal. The hospital is run by the government, but supported by the Nick Simons Institute. His manager Dr. Rakesh Shrestha is a medicals maintenance of the Jiri Hospital. The script of the video is given below. In this script one can read how both doctors emphasize the importance of having an active and involved BMET within a hospital. Also the script reads the difference the BMET can make to the overall performance of the hospital and the experience of being successful.

*[Uttam Pokhrel]*

*Hi Namaste, I am Uttam Pokhrel I work as a Biomedical Equipment Technician in Jiri Hospital in Dolakha. This is our district hospital run by the government of Nepal. It has been three years, I have been serving this hospital as BMET. As a BMET, my job is to install the required medical equipment and to perform maintenance. I am also responsible to troubleshoot potential problems. I ensure that all the medical equipment and instruments are safe to use and running at all times effectively. I plan my work carefully; I work in collaboration with the clinical staff to ensure that they are confident in using the biomedical equipment. I work to guide treatments can be conducted in an uncompromised way. I really feel honoured and recognized when doctors and nurses praise my work. I really feel proud when I receive positive compliments. I recall doctors and nurses telling me that I make a significant contribution even without prescribing medicine or nursing the patient. The faster and better I do my job and repair equipment, the more recognition and gratitude I receive. I have learned many things*

*from the Jiri Hospital team and the Nick Simons Institute. Also I would like to state that I have learned from the challenges as well. This way of learning is a great experience.*
*Thank you!*

*[Dr. Rakesh Shrestha]*
*Namaste, I am Doctor Rakesh Shrestha, medicals maintenance of Jiri Hospital, Dolakha. Today I would like to share with you, about my colleague mister Uttam Pokhrel and his work as a BMET in our hospital. Mister Pokhrel has been working in this hospital for more than three years. He is one of the most important human resources that we have in our hospital. He installs all our biomedical equipment and does maintenance on all the equipment. One thing I would like to highlight about him is his attention to his tasks. He controls the condition of the biomedical equipment every day. It is the reason why we feel confident about our equipment during surgery and treatment. Also that the medical equipment is fixed is something that helps us in our work. When something is wrong with the equipment, he quickly fixes it or performs tasks to fix it during this and for our resources we have requested him to provide input during our planning process as well. We have given him the management responsibilities in addition to his regular tasks as BMET. We are very happy to have mister Uttam Pokhrel in our team and a special thanks to the Nick Simons Institute for providing us with a competitive, hardworking and responsible person.*

In addition to the motivational video, a job description will be showed to half of the participants; same half that is exposed to the motivational video. This job description must educate participants on the exact responsibilities of a BMET. This will enable them to learn in a more focused manner during the Pilot Course. The job description contains the following responsibilities:

- Develop/ maintain inventory of the Biomedical equipment
- Develop a preventive maintenance (PM) schedule, conform standard guidelines and perform the PM accordingly
- PM should be performed according to the standard checklist. The Checklist should include:
    - Tidiness of the equipment
    - Functional checks
    - Safety checks
    - Integrity of accessories
    - Maintain log
- Perform corrective maintenance as required, which includes:
    - Troubleshoot to determine the error
    - Repair the error
    - Perform safety test and function test after repair
    - Maintain log
- Perform user's training on Biomedical equipment for clinical staff and support staff
- Provide technical input to hospital management on purchasing, commissioning, decommissioning and disposal of biomedical equipment.
- Ensure minimum stock of frequently required consumables and spare parts (including batteries, cleaning material etc).

The expectation from this research is that being exposed to the motivational video and a clear job description will intrinsically motivate participants to perform better within the Pilot Course. Understanding the importance of the profession and the potential recognition a BMET receives within the hospital when being successful, must encourage participants to perform better in the Pilot Course. It must encourage them both to become ambitious and successful when working, but on short term and most relevant to this research, this must be reflected in finalizing the Pilot Course with better results compared to participants not exposed to the job description and motivational video. This last effect is the most important effect, since within the scope of this research this is the only measurable effect.

### 3.2.B Study Validation

Before initializing the actual pilot, the Pilot Course had to be validated. Therefore, a pre-pilot was created. The pre-Pilot was a short test running among a group of experts and educated volunteers without knowledge of this application. The combination of experts and participants without any knowledge or experience in the application provided a complete feedback overview, both focused on content, setup and design. The test setup was comparable to the actual Pilot Course that had been developed. The pre-pilot enabled final improvements and adjustments, based on the feedback given by the participants of the pre-pilot. The validation group was built up from a group of nine participants, out of which five experts in this application, three people with experience in this application and one participant without any relevant experience. Focus was on details of the content of the course; question formulation, clarity of the design, etc. In summary, running the pre-pilot helped to optimize the Pilot Course and validated the setup of this research. Results of the pre-pilot can be found in the next chapter.

### 3.2.C Study Metrics

The stated hypothesis will be tested, by measuring the improvement as well as the performance from the participants to analyse whether a desired level of knowledge and a desired set of capabilities among participants is indeed reached. In addition, the performance and the improvement in performance of participants exposed to the motivational incentives compared to participants not exposed to the motivational incentives is analysed to verify the possibility to stimulate intrinsic motivation during training. Performance will be analysed by measuring overall performance throughout the Pilot Course, based on the grading explained earlier. It is assumed that exposed participants will score a higher overall grade compared to not exposed participants. However, some participants might have prior knowledge and experience where others might have no knowledge or experience on the topic at all. To analyse results, eliminating this bias, improvement made throughout the course is measured as well. This is done by comparing results for the Knowledge Quiz, assessed in the beginning of the course before being exposed to theory, to results for the Final Assessment.

In addition to measuring improvement and performance, two surveys have been added to the Pilot Course in order to collect data from the participants. One survey in the beginning of the course, questioning expectations of the Pilot Course and personal information from participants; prior experience, age, level of education and technical aspects affecting their participation, like device they will use and internet reliability. The second survey is added at the end of the course, following the Final Assessment. This is a feedback survey, in which we request feedback on the Pilot Course. In addition to feedback we question whether their expectations were met. The exact questions and setup of both surveys can be found in Appendix E.

### 3.2.D Data Collection

Data collection for this research was done by running the Pilot Course and by sending out surveys among a group of volunteering participants. Participants were recruited via various channels; (1) international contacts from the Technical University of Delft, (2) contacts from the Nick Simons Institute and (3) the Infratech platform. Reasoning for these platforms is mostly practical and follows the target group of this research. Contacts from the Technical University (TU) Delft is a practical consideration, since this research is performed commissioned by the TU Delft. The collaboration with the NSI is initiated because of their knowledge and experience in this application in LMIC. Lastly, the Infratech platform is an international platform to spread information, requests or researches. Via that platform a large group of interested experts in the field of Biomedical Engineering was reached, subsequently creating new contacts and platforms. Via all those contact points, indirect new contacts were created via individuals interested in the subject and willing to support or even cooperate in this research. A survey, referred to as 'The Design of a BMET MOOC' was sent out to all mentioned contacts and could again be forwarded by individuals willing to help and cooperate. In this survey general questions where formulated to request input on the design of a MOOC to train BMETs. In addition, the survey questioned if people were willing to participate in a Pilot Course. If so, contact details where collected, which build the network for the Pilot Course.

As explained before, this research aims to, in addition to analyse the possibility to educate BMETs via an online platform, investigate the difference between a group being exposed to motivational incentives and a group not being exposed to motivational incentives. In addition, a different research simultaneously runs on this Pilot Course. Therefore, four different groups had to be created among the participants being exposed to different material. The second research running on this Pilot Course investigates the influence of interactive learning versus passive theory-based learning[4]. So all together four different, so called 'Cohort Groups' had to be created; (1) Group A – Exposed and Interactive, (2) Group B – Exposed, (3) Group C – Not Exposed and Interactive and (4) Group D – Not Exposed. The deviation of participants over the different groups had to be done evenly. Meaning participants coming from similar regions or with similar experience or knowledge had to be equally spread over the four different cohort groups. Results of how participants were divided over these four groups can be found in the next chapter.

### 3.2.E Execution

After allocating each participant in a cohort group, the pilot was initiated. Participants were given a period of two weeks' time to complete the Pilot Course, which was expected to take approximately four till six hours only. The time span of two weeks was chosen to allow flexibility for the participants to complete the Pilot Course whenever suitable. Participants who had indicated that they were willing to participate and were thus allocated to a cohort group were contacted via email and edX. The email gave instructions how to enrol and further explained the research behind this Pilot Course. Via the email received from edX, participants could register and subsequently start the Pilot Course.

[4] Research performed by Daniel Garcia de las Heras; 'Fundamentals for the Design of a MOOC to train Biomedical Equipment Technicians in LMIC'

Throughout the course, two reminders were sent to all participants who had not yet completed the Pilot Course. The first reminder was sent after one week and another reminder was sent three days prior to the deadline. Different emails were sent to participants in progress and participants who had not started the Pilot Course yet. A third mail was sent at the day of the deadline, informing participants in progress that the deadline had been extended by two more days, giving them the opportunity to complete the Pilot Course. The last communication was done after closing the Pilot Course, to express gratitude to all participants for participating in this pilot.

## 3.3. Definitions and Corrections

Before visualizing results, some relevant definitions will be explained in greater depth to ensure that all results are correctly interpreted. First of all the 'Exposed Group' is the group exposed to the motivational incentives, where the 'Not Exposed Group' is the group which was not exposed to the motivational incentives.

Secondly, the Total Grade, which is the overall grade given to participants for their performance in the Pilot Course. This grade comes as a result from the grading mechanism that was explained earlier this chapter. This grade was calculated by edX and adjusted slightly by hand based on the grading mechanism as given in Table 3.1.

Thirdly, all Boxplots used to illustrate results are divided into quartiles, where the mean is illustrated with a line within the boxplot and the median with a cross.

Fourthly, when calculating significant differences, an alpha value of 0.05 was assumed in all tests and conclusions. This value is precise and accurate.

Lastly, A Pearson product-moment correlation coefficient of 1 signifies a perfect positive correlation, equally a correlation coefficient of -1 signifies a perfect negative correlation. A correlation coefficient approaching zero means no correlation exists.

When analysing results, a differentiation was made between 'Participants who have started the Pilot Course', 'Participants who have completed the Pilot Course' and 'dropouts'. Participants who have started the Pilot Course are participants scoring above 0% for the Knowledge Quiz. Participants who have completed the Pilot Course are participants scoring above 0% for the Knowledge Quiz, above 50% for the Final Assessment and above 50% as Total Grade. With dropouts, we refer to participants who have not completed the Pilot Course. Participants are considered as dropout if they had a score below 50% as Total Grade or a score below 50% for the Final Assessment and a corrected score of 0% for the Knowledge Quiz. The threshold was set at 50% based on analyses of the scores, where it was assumed that, independent of capabilities and knowledge, a minimum score of 50% must be achieved with limited effort provided. It was concluded based on scores for other subcategories that participants scoring below the threshold either stopped halfway or 'clicked through' the course, but did not participate with focus or dedication. Dropout- or completion rate is relevant data, but will be analysed separately. This to avoid that by analysing the quality of results, dropouts effect the data incorrectly.

The 'Corrected Scores Knowledge Quiz' are participants scores for the Knowledge Quiz corrected based on level of difficulty, compared to the level of difficulty of the Final Assessment. So the 'Corrected Scores Knowledge Quiz' are normalized Knowledge Quiz results. This level is established with a small test where a group of 15 participants, who have not participated in the Pilot Course and without any knowledge or experience in Biomedical Engineering. Half of the group, eight participants, completed the Knowledge Quiz and subsequently the Final Assessment. The other half, seven participants, completed both assessments in opposite order, eliminating order bias. All participants were excluded from any theoretical background knowledge or content from the Pilot Course. Results from this test can be found in Table 4.1 in the next chapter. Conclusions from this research were based on corrected Knowledge Quiz results. Results visualized in Chapter 4 are all based on the corrected Knowledge Quiz results.

Finally, in order to analyse the data with statistical tests, we must ensure that group sizes are equal in order to perform the Two-Way ANOVA. The Two-Way ANOVA is performed to analyse the influence of the different cohort groups. Therefore group sizes were set to an equal number of participants, where data points of additional participants were filtered out, based on moment of completion. So participants finalizing after the set amount was reached were left out of this research analyses. If data was filtered as described, a footnote has been added.

# 4

# Results

This chapter elaborates on the results found within this research, which resulted from running the Pre-Pilot, the Pilot Course and all four surveys. The chapter will start with the results of the validation process. Subsequently the deviation of participants over the different cohort groups is explained. This is followed by the results of the Pilot Course itself, including corrections made and feedback on the motivational incentives. The chapter ends with an elaborated overview of the insights on the setup and design of the Pilot Course and requested setup of design of the MOOC, resulting from different surveys.

## 4.1. Validation Process

Before initiating with the Pilot Course, a twostep validation and preparation was performed; a survey was done to measure design and setup preferences of potential participants and a pre-pilot to verify the setup and content of the Pilot Course. This section will elaborate on the results of the validation, results of the pre-pilot and the results of the survey specifically. Additional results are not relevant or will be covered when discussing results of the Pilot Course.

As explained in the previous chapter, a survey was spread among the network created and forwarded to an extended network; Designing an online BMET Training. This survey aimed to collect data on an optimized design and setup of the final MOOC. In addition this survey aimed to create a network of people willing to participate in the Pilot Course. This sub section will elaborate further on the primary aim; requesting input on design and setup of a final MOOC. This subsection will only elaborate on relevant outcomes.

Figure 4.1 below illustrates the medium participants would use when participating in an online training or MOOC. What becomes clear is that the majority would be using a computer; either desktop or laptop. However, more a large group indicates they would be using a smartphone. This signifies the final MOOC and the Pilot Course must be designed suitable for both mediums. No limitation must occur due to use of smartphones.

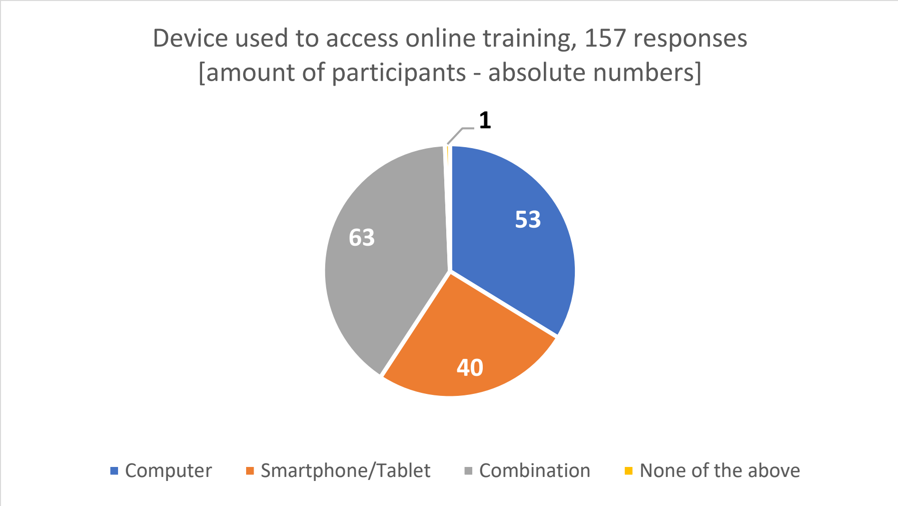



FIG. 4.1 Medium participants would use to participate in an online training or MOOC.

Figure 4.2 below illustrates most respondents would access the MOOC from home or work, since internet is most reliable there. The figure illustrates almost half of the respondents is bound by internet accessibility, which obviously reduces flexibility. This must be considered when setting deadlines and submission schemes for the MOOC or Pilot Course.

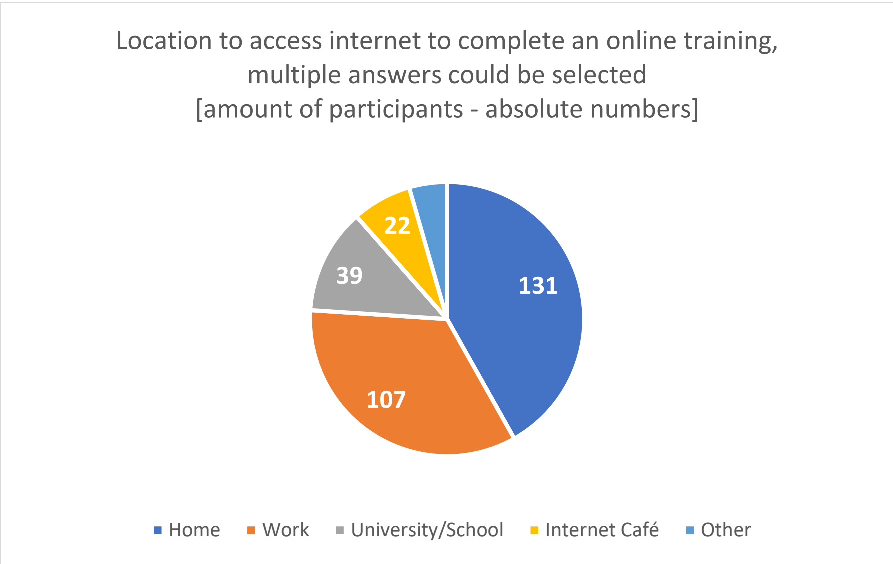



FIG. 4.2 Location of internet access, among potential participants.

When creating the content of both the Pilot Course and final MOOC, the total duration proved to be a difficult topic. Since at this stage, it is unknown if participants would experience the training as fulltime education or would have to find time to participate whilst having a full-time job or education. Figures 4.3 and 4.4 below indicate respondents are willing to spent maximum 6 hours per week on an online training or MOOC, but ideally less, approximately 4-6 hours. Same applies for the Pilot Course, the majority indicates willing to spent less than 4 or 4-6 hours only. This implies people will not perceive the final MOOC as full-time education, but will participate next to other occupations.

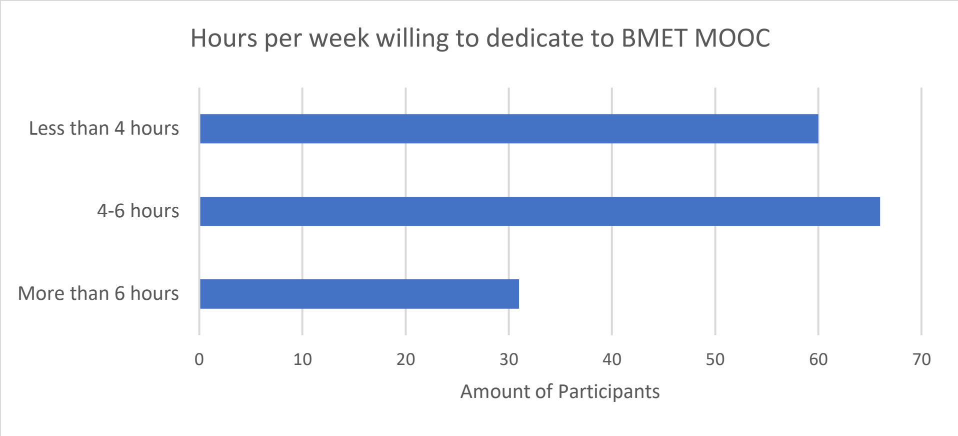



FIG. 4.3 Time willing to spent per week on an online BMET Training or MOOC.

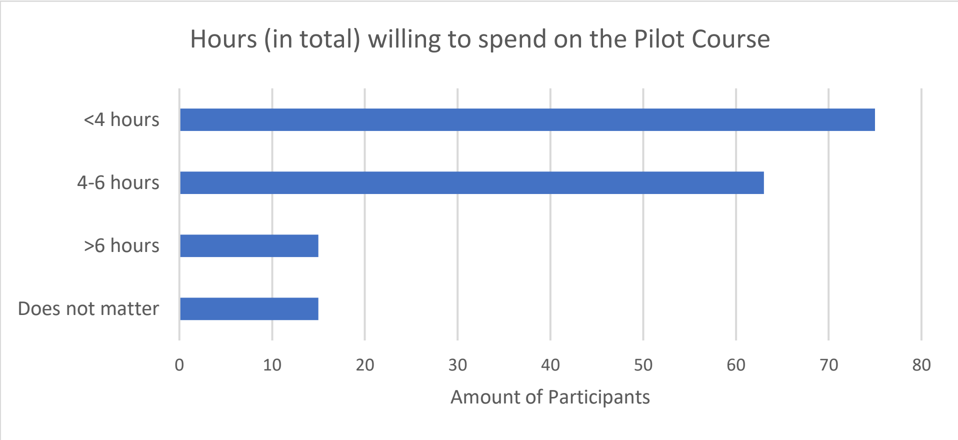



FIG. 4.4 Time willing to spent in total on the BMET Pilot Course.

This survey created a network of 119 people willing to participate in the Pilot Course. The group of participants is mainly from Africa and South-East Asia and contains quite a variety of pre- knowledge and different professions, but almost all participants are somehow related to or involved with Biomedical Engineering.

In addition to the described survey, a pre-pilot had been conducted to gather final feedback and to enable optimization of the Pilot Course. In general all participants of the pre-pilot were positive about both the setup of the Pilot Course as well as the research in general. Content was praised for clarity, completeness and the setup of the course was praised. Feedback was given in quite some detail; small adjustments on question formulation, small adjustments on possible answers to questions, spelling errors and minor design tweaks. Therefore overall the pre-pilot functioned effectively as a confirmation for a proper setup and design of a relevant research.

## 4.2. Participants

For the actual pilot, as indicated before, a group of 119 participant was invited. This group was formed by responses to the survey 'The Design of a BMET MOOC', in which participants indicated they were willing to participate. Relevant characteristics of the contacted participants are visualized in the figures below. All numbers in the below figures are absolute numbers.

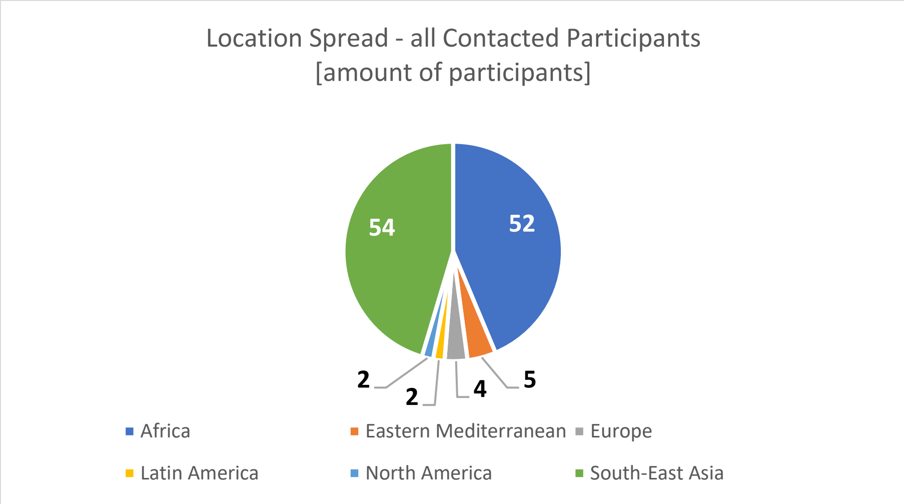



FIG. 4.5 Location Spread of all contacted participants for the Pilot Course.

Figure 4.5 shows the spread in location among participants, referring to the spread of where participants are currently working and living. What we can see is that the majority of the contacted participants is currently located in Africa and South-East Asia. The explanation for the large number of participants from South-East Asia is the network contacted by the Nick Simons Institute, focussed in Nepal. The large number of participants from Africa is contacted partly via June Madete, a contact from Delft University of Technology, currently active as biomedical engineer from Kenya. The other part of the large responses from Africa is via the Infratech platform and the network created indirect via Infratech.

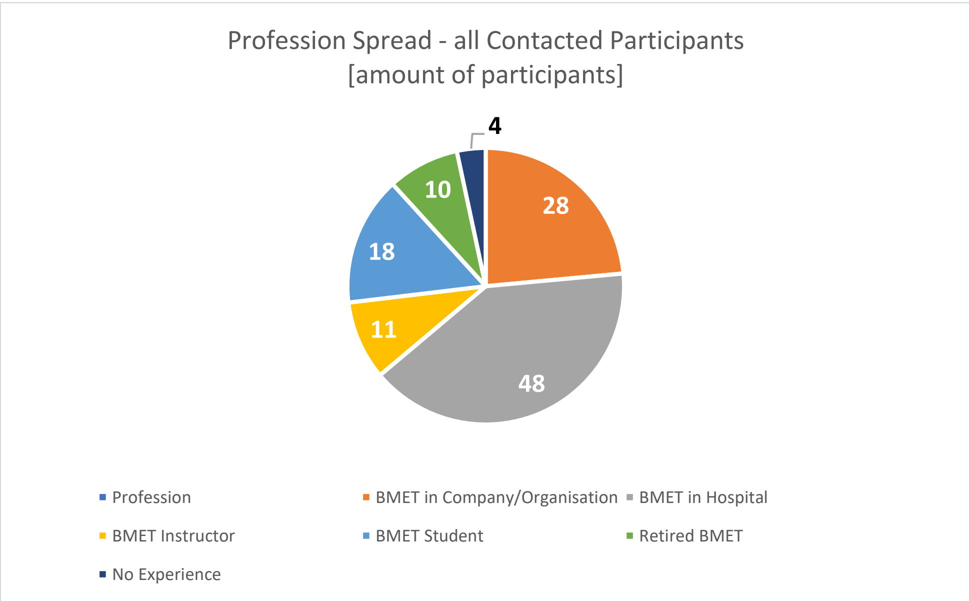



FIG. 4.6 Profession Spread of all contacted participants for the Pilot Course.

Figure 4.6 illustrates the professions of all contacted participants. Visible is that the majority of participants is currently active as BMET, either in a hospital or in a company or organisation.

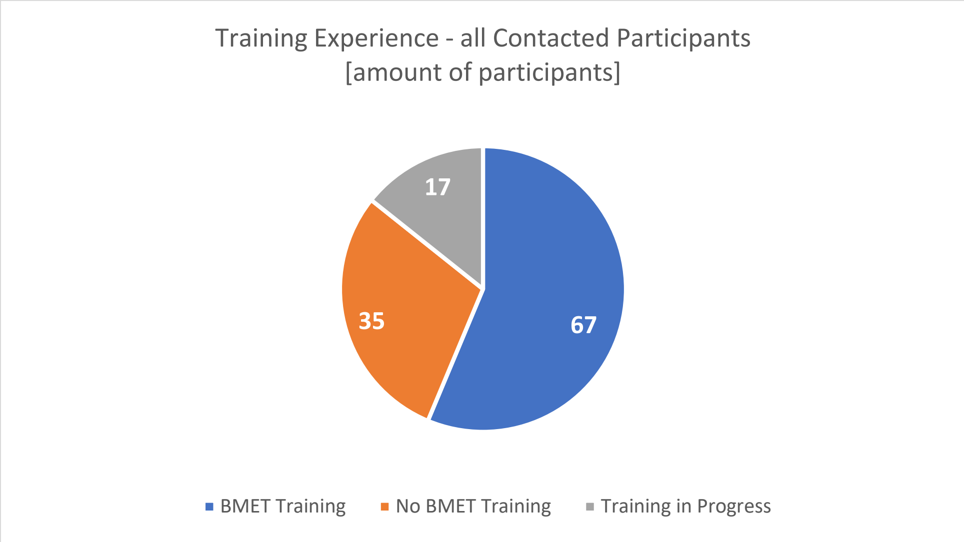



FIG. 4.7 Training Experience of all contacted participants for the Pilot Course.

The last figure, Figure 4.7 illustrates the training experience in the Biomedical Engineering field, of all contacted participants. The majority of the participants has already followed a BMET training in the past, as illustrated in blue. Approximately a quarter has never followed any form of BMET training, as illustrated in orange and a small part of the participants is currently following BMET training. The last group is following a training via the Nick Simons Institute and is contacted via them.

The participants referred to above were assigned to four different cohort groups, as discussed in the previous chapter. The cohort groups can be summarized as follows; (1) Group A – Exposed and Interactive, (2) Group B – Exposed, (3) Group C – Not Exposed and Interactive and (4) Group D – Not Exposed. The deviation of participants over the different groups is visualised in the figures below, again in absolute numbers.

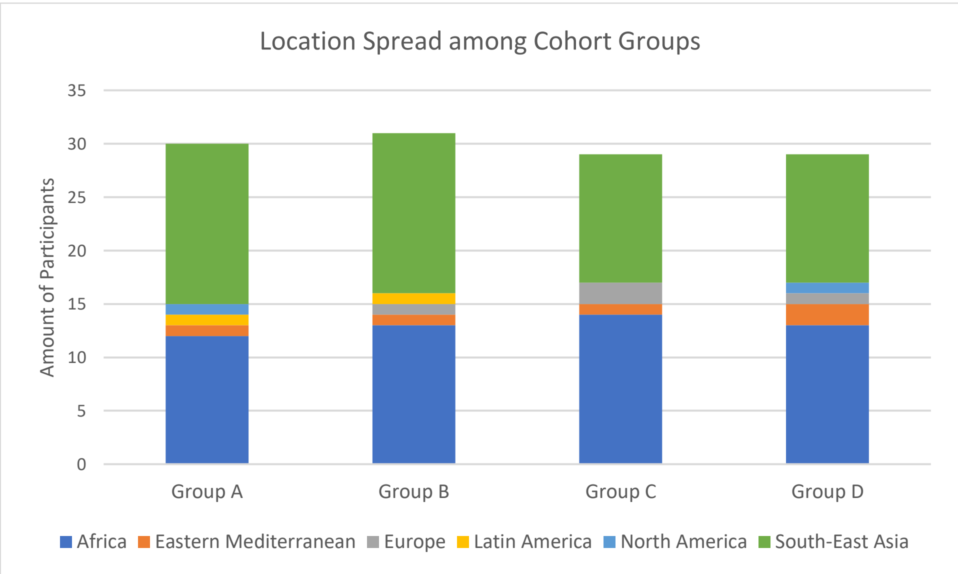



FIG. 4.8 Location Spread among different Cohort Groups.

Visible in Figure 4.8 is the location spread among different cohort groups. In other words, Figure 4.8 illustrates the deviation per cohort group of where participants are currently located. Most relevant locations, relevant due to sample size, are Africa and South-East Asia. We see that these two locations are evenly distributed over the different groups.

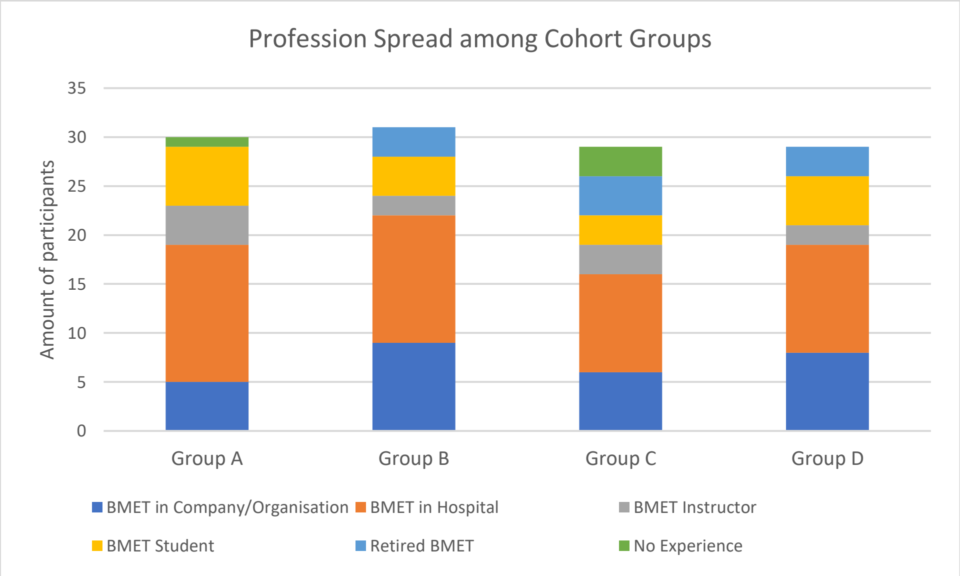



FIG. 4.9 Profession Spread among different Cohort Groups.

The figure above, Figure 4.9 illustrates the deviation per cohort group of the profession of participants. Visible is that the most important profession groups, BMET in hospital and BMET in Company/Organisation, are evenly distributed among the cohort groups.

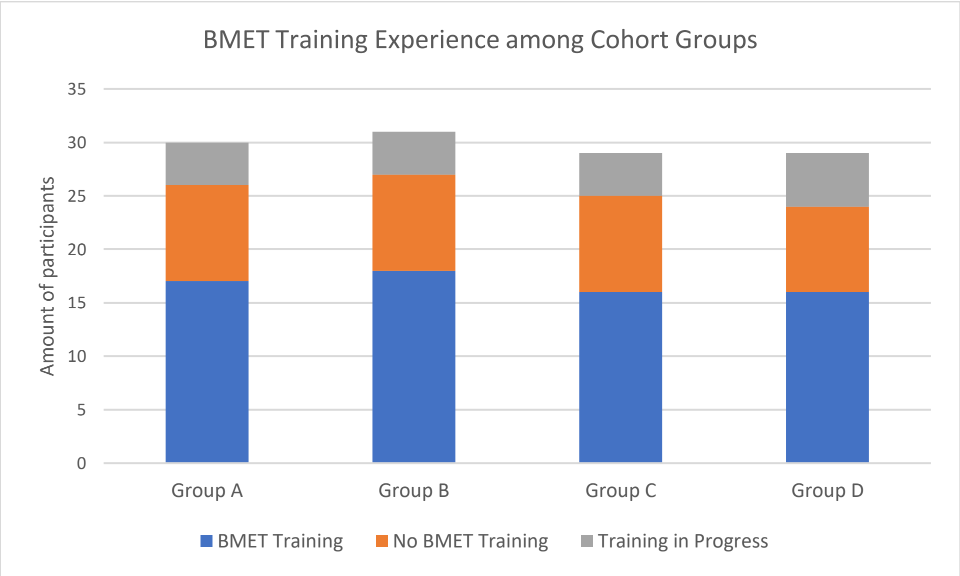



FIG. 4.10 BMET Training Experience spread over different cohort groups.

Figure 3.6 above illustrates the deviation of BMET Training experience of participants over the different cohort groups. As you can see all three possible experience levels are evenly distributed among the four cohort groups.

In addition, visible in all three graphs is that each cohort group contains almost an even number of participants. All groups contain approximately 30 participants.

## 4.3. The Pilot Course

The Pilot Course existed of a number of questions within the platform edX and two surveys. This section elaborates on the pre-survey, exposed to participants via edX but completed using Google Forms, on the results from the Pilot Course itself in edX and the results of the feedback survey, also exposed to participants via edX but completed using Google Forms. Relevant results and correlations made on results are shown graphically in this section.

### 4.3.A Corrections

As explained in Chapter 3, the 'Corrected Scores Knowledge Quiz' are participants scores for the Knowledge Quiz corrected based on level of difficulty, compared to the level of difficulty of the Final Assessment. This level is established with a small test where a group of 15 participants, who have not participated in the Pilot Course and without any knowledge from or experience in Biomedical Engineering. Results from this test can be found in Table 4.1 below. In this table, the order of completion is given, where 1 represents (1) Knowledge Quiz followed by (2) Final Assessment and 2 represents (1) Final Assessment followed by (2) Knowledge Quiz.

| # | Order of Completion | Score Knowledge Quiz | Score Final Assessment |
|---|---|---|---|
| 1 | 1 | 50% | 47% |
| 2 | 2 | 67% | 37% |
| 3 | 1 | 77% | 53% |
| 4 | 2 | 60% | 50% |
| 5 | 1 | 44% | 31% |
| 6 | 2 | 71% | 61% |
| 7 | 1 | 67% | 55% |
| 8 | 2 | 25% | 34% |
| 9 | 1 | 48% | 28% |
| 10 | 2 | 63% | 27% |
| 11 | 1 | 38% | 35% |
| 12 | 2 | 67% | 43% |
| 13 | 1 | 83% | 77% |
| 14 | 2 | 83% | 66% |
| 15 | 1 | 65% | 55% |

TABLE 4.1 Results normalisation Knowledge Quiz results bases on level of difficulty.

The figures below show the analyses of these results. The first two figures, Figure 4.11 and 4.12 show the distribution of the results for both assessments. From the figures it is hardly visible, but by performing the Kolmogorov Smirnov test we learn both distributions are normal.

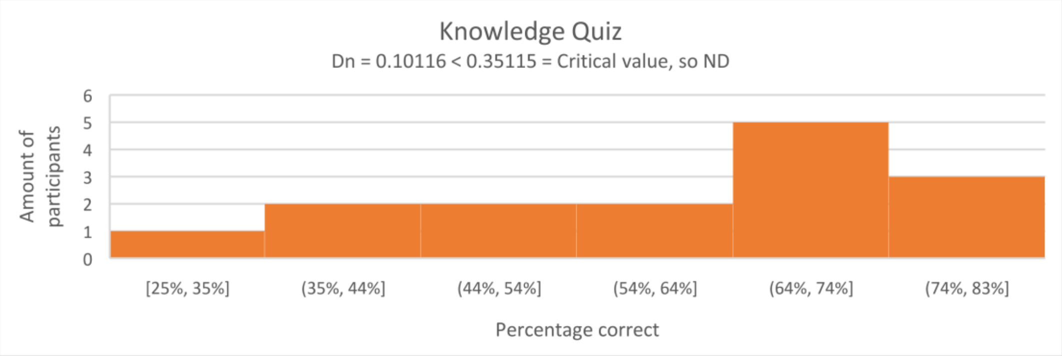



FIG. 4.11 Normalization Assessment Grades – Distribution Knowledge Quiz Results.

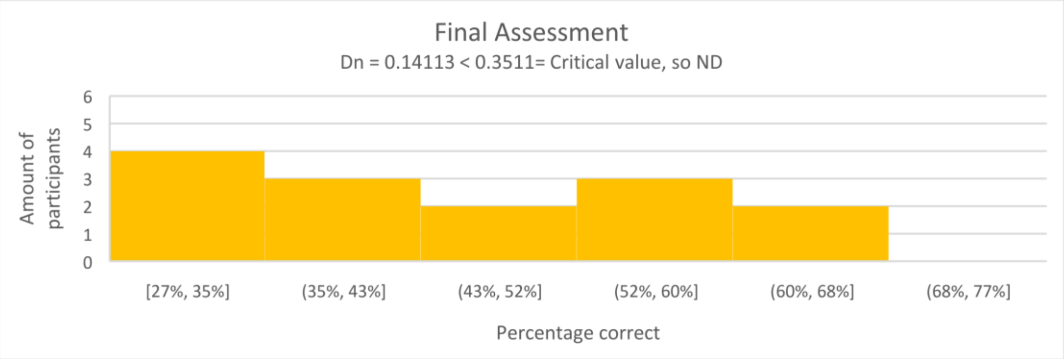



FIG. 4.12 Normalization Assessment Grades – Distribution Final Assessment Results.

The boxplots of both results are shown in Figure 4.13 below. The figure illustrates what we learn from performing a t-test; the difference between the results for the assessments is significantly different. This can be derived from the calculations resulting in a p-value of 0.024, which is lower than the set alpha value of 0.05.

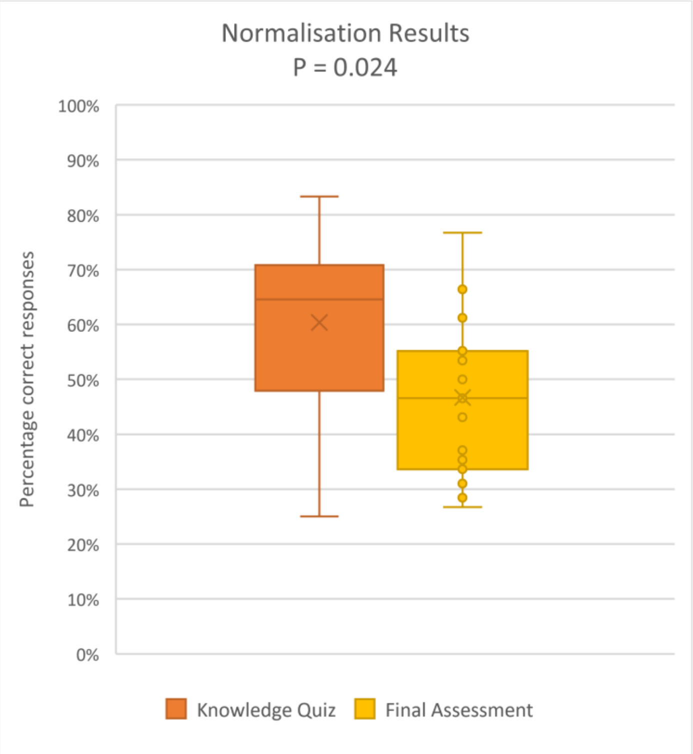



FIG. 4.13 Normalization Assessment Grades – Boxplots results Knowledge Quiz and Final Assessment.

Based on this conclusion, the scores for the Knowledge Quiz used for further analyses must be normalized. This will be done by taking the medians of both assessments, to limit influence of outliers. The medians are; Knowledge Quiz 65% and Final Assessment 47%. So it can be concluded that the Final Assessment is more difficult than the Knowledge Quiz, corresponding to a factor of 1.39. Therefore the corrected Scores for the Knowledge Quiz are the scores for the Knowledge Quiz divided by the found difficulty level factor of 1.39. From here on, the normalized results will be used solely.

### 4.3.B Feedback Motivational Video

Another important set of results, before analysing the results of Pilot Course itself, is the feedback given on the motivational video, by participants exposed to the video. Of the complete group who have actually participated in the Pilot Group and where allocated to the Exposed Group, 90% indicated that they had watched the complete video. The respondents also stated the length of the video was about right (95%), only 5% responded the video was too short. Subsequently, respondents were asked to rate the video on several aspects. In the figures below, it is visible respondents where overall really positive about the video.

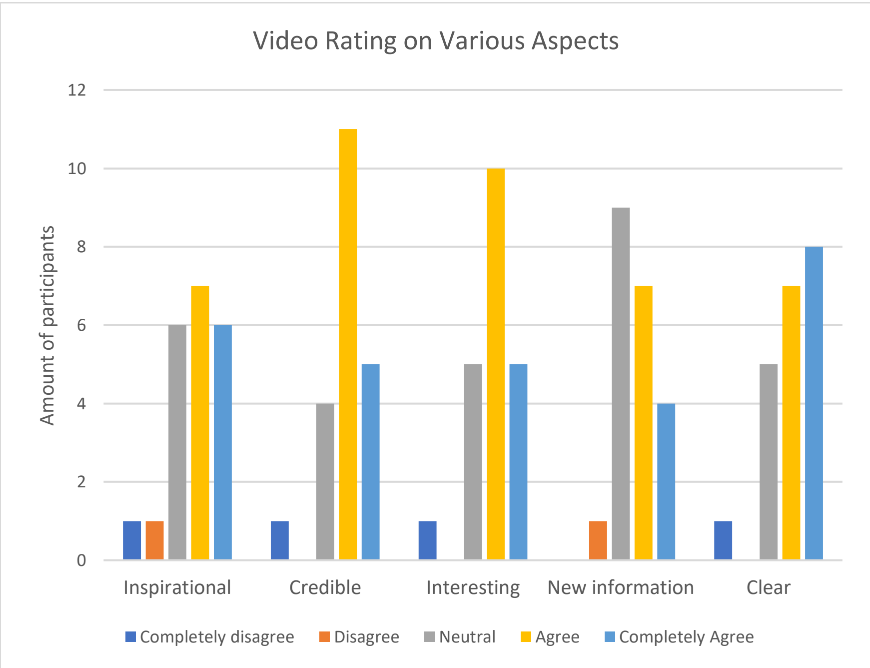



FIG. 4.14 Rating content aspects of the motivational video.

Figure 4.14 given above, shows participants experienced the motivational video mainly as credible and interesting, but judged all questioned aspects mostly positive. Figure 4.15 given below illustrates how participants rate the technical aspects of the motivational video. Visible is that all aspects were mostly conceived as good.

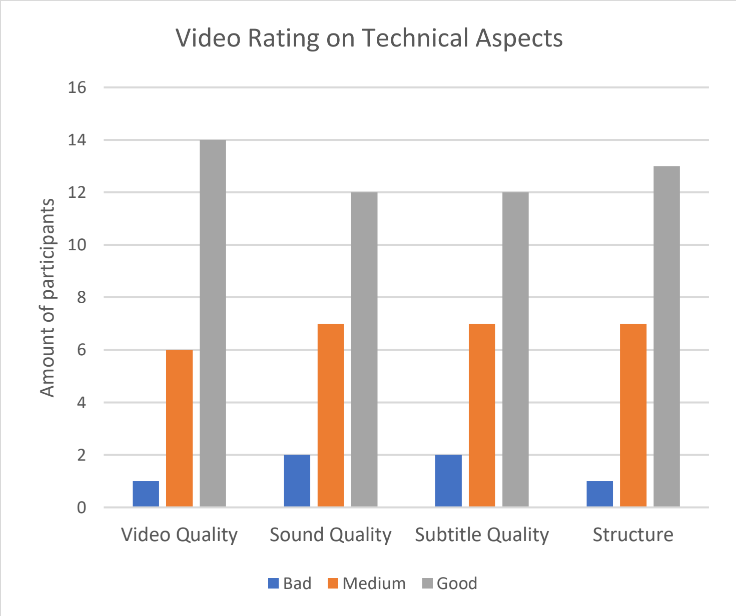



FIG. 4.15 Rating technical aspects of the motivational video.

Figure 4.16 below illustrates how motivating respondents rated the video. Where the majority of the participants indicated that the video had a positive impact, corresponding to a high rating, on their motivation to complete the Pilot Course.

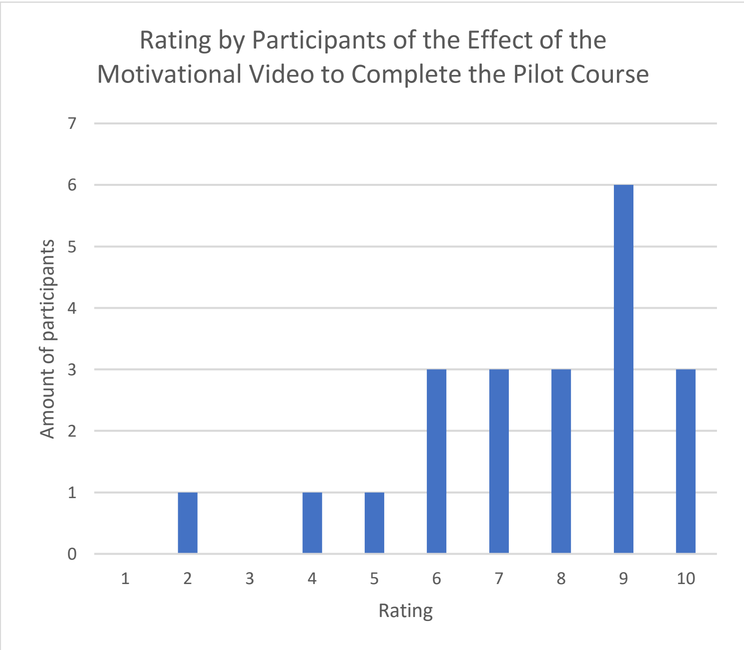



FIG. 4.16 Impact of the video on motivation.

Some quotes of respondents explaining why or how the video motivated them:
‘*The video showed the role of BMET and the importance of BMET to the hospital. He also proved that hard work and dedication towards the job will lead towards the success.*’ and ‘*As I am working as a biomedical technician since six years in government hospital, I am clear about the role of biomedical technician in health facilities. After seeing this video I am more motivated to give my contribution to health facilities as biomedical technician*.

### 4.3.C Influence Cohort Groups on Performance and Improvement

As described before, four different cohort groups were created, in order to perform two different researches on this Pilot Course; this research focusses on the possibility to train and motivate participants to become a successful BMET, whereas the other research investigates the effectiveness of interactive content[5]. This subsection will analyse the influence of the four different cohort groups on the results and the difference between results. Focus will be on the effect of the motivational incentives, however whilst analysing the influence of the second variable; interactive versus not interactive content, will be considered.

Let us first analyse all unfiltered data, in which we include all participants who have initiated the Pilot Course, so with a score for the Total Grade (TG) of above 0%. Figure 4.17 below illustrates the improvement of all unfiltered data. This figure is created to visualize all data from this research.

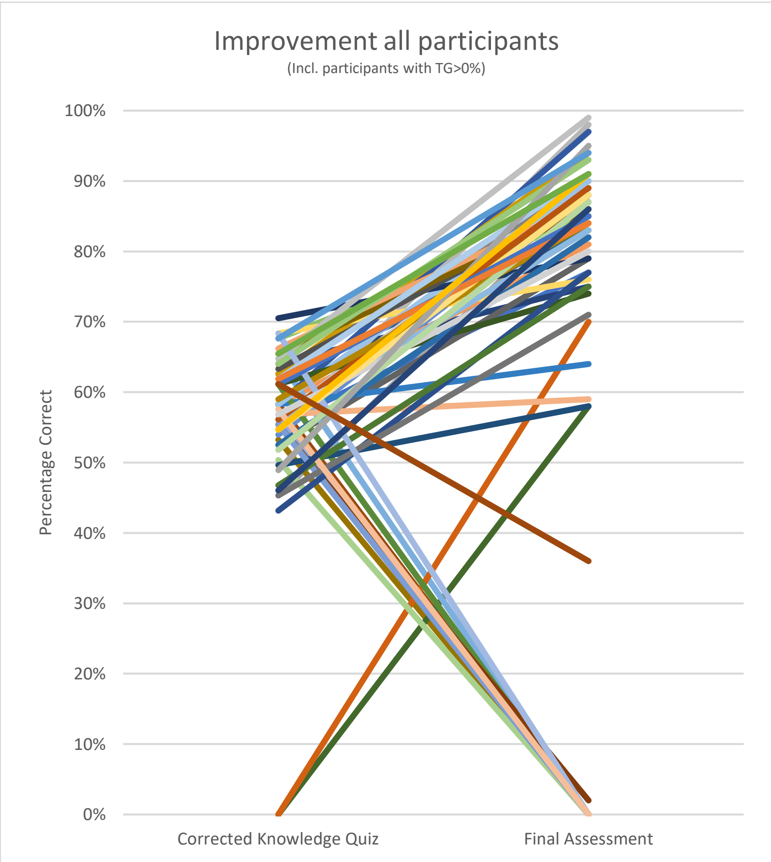



FIG. 4.17 All data summarized in improvement, excluding all participants with a TG score of 0%.

However, more relevant than the data above is the data of all participants excluding dropouts. Dropout or completion rate is relevant data, but will be analysed in one of the following sections. This section focusses on results, where dropouts effect the data incorrectly. The graph above shows this effect clearly. Results where the discussed filters are added are shown below in Figure 4.18[6].

[5] Research performed by Daniel Garcia de las Heras; 'Fundamentals for the Design of a MOOC to train Biomedical Equipment Technicians in LMIC'.

[6] In order to analyse the data, group sizes must be equal. Therefore all group sizes were set to an equal number of participants, where data points of additional participants were filtered based on moment of completion. So participants completing after the set total number of participants was reached were left out of this research analyses and are thus not visualized in this and following figures. As described in Chapter 3.

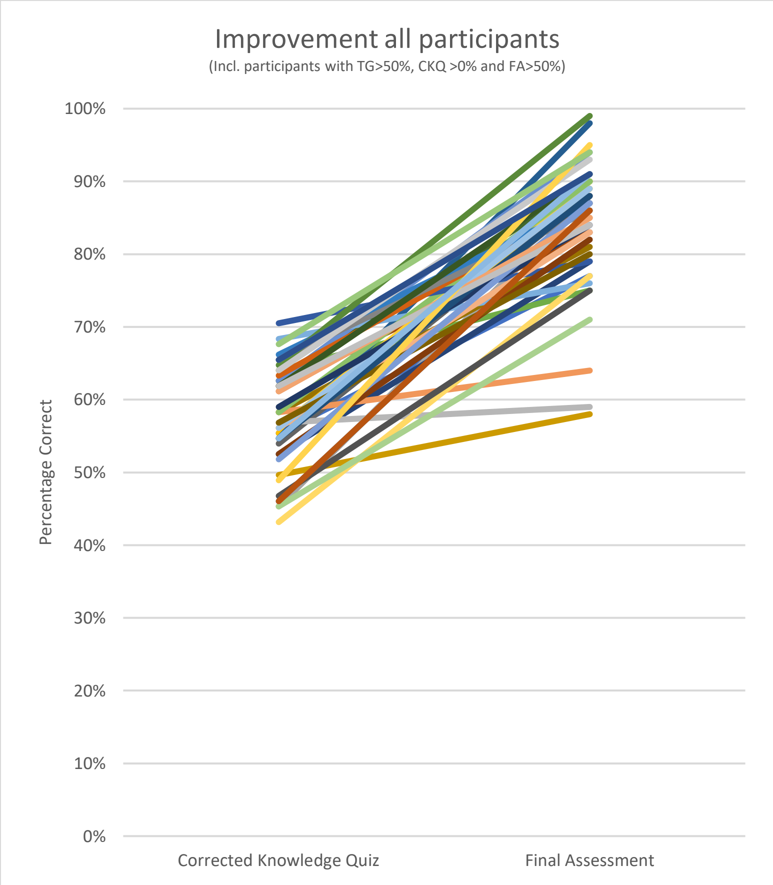



FIG. 4.18 Filtered data summarized in improvement, excluding all participants with a TG score <0%, CKQ score of 0% and a FA score <50%.

What we see in Figure 4.18 is that participants in general made improvement throughout the course. However, the question remains what the influence of the different cohort groups on these results is. That is visualized in Figure 4.19 below. In this figure boxplots are given for each different cohort group; (1) Group A – Exposed and Interactive, (2) Group B – Exposed, (3) Group C – Not Exposed and Interactive and (4) Group D – Not Exposed. The boxplots are given for the corrected Knowledge Quiz scores and for the Final Assessment scores in order to visualize improvement. What we can see is that for each group the median and mean are almost equal. However, in order to statistically prove significance differences, statistical tests were performed. Initially it was concluded the data is normally distributed with a Kolmogorov Smirnov test. It was found that the calculated value for the corrected Knowledge Quiz scores is equal to 0.0839, which is smaller than the critical value of 0.2050. Therefore we can conclude the corrected Knowledge Quiz scores are normally distributed. Equally we found that the calculated value for the Final Assessment scores is equal to 0.1063, which is smaller than the critical value of 0.2050. Based on that outcome, a Two-Way ANOVA test with replication could be performed. It was found in the Two-Way ANOVA test with replication for the corrected Knowledge Quiz scores (CKQS) that there is no significant difference between the Exposed and the Not Exposed Group. The calculated value of 0.435 is smaller than the critical value of 4.085. The p-value of 0.513 confirms this conclusion. In addition no significant difference can be found between the Interactive and not Interactive Groups. The calculated value of 2.669 is smaller than the critical value of 4.085. The p-value of 0.110 confirms this conclusion. Lastly, the interaction between variables was analysed, however once again it can be concluded there is no significant difference and thus correlation between variables. The calculated value of 1.279 is smaller than the critical value of 4.085. The p-value of 0.265 confirms this conclusion.

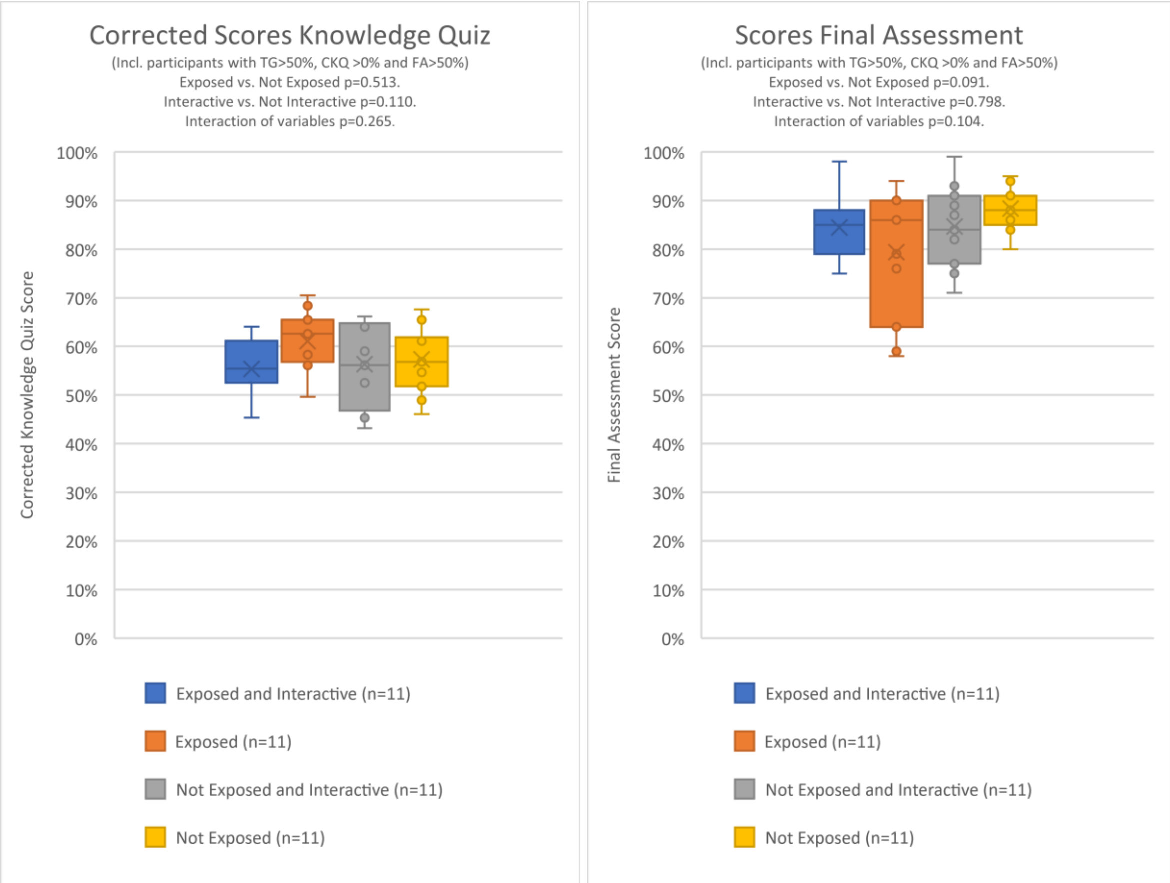



FIG. 4.19 Improvement per cohort group of filtered data in boxplots, excluding all participants with a TG score <0%, CKQ score of 0% and a FA score <50%.

Apart from improvement made by participants, let us analyse performance which is measured by the Total Grade (TG) received by participants. This is visualized in Figure 4.20 below. In this figure boxplots are given for each different cohort group, as before. The boxplots are given for the Total Grades to illustrate Performance. This shows that for each group the median and mean are close to each other and hardly differ between cohort groups. In order to statistically prove significant differences, statistical tests were performed. Initially it was concluded the data is normally distributed with a Kolmogorov Smirnov test. It was found that the calculated value is equal to 0.2064, which is almost equal to the critical value of 0.2050. Therefore we can conclude the Total Grades are approaching a normal distribution. Based on that conclusion, a Two-Way ANOVA test with replication could be performed. It was found in the Two-Way ANOVA test with replication, that there is no significant difference between the Exposed and the Not Exposed Group. The calculated value of 2.951 is smaller than the critical value of 4.085. The p-value of 0.094 confirms this conclusion. In addition no significant difference can be found between the Interactive and not Interactive Group. The calculated value of 0.414 is smaller than the critical value of 4.085. The p-value of 0.524 confirms this conclusion. Lastly, the interaction between variables was analysed, however once again it can be concluded there is no significant difference and thus correlation between variables. The calculated value of 0.700 is smaller than the critical value of 4.085. The p-value of 0.408 confirms this conclusion.

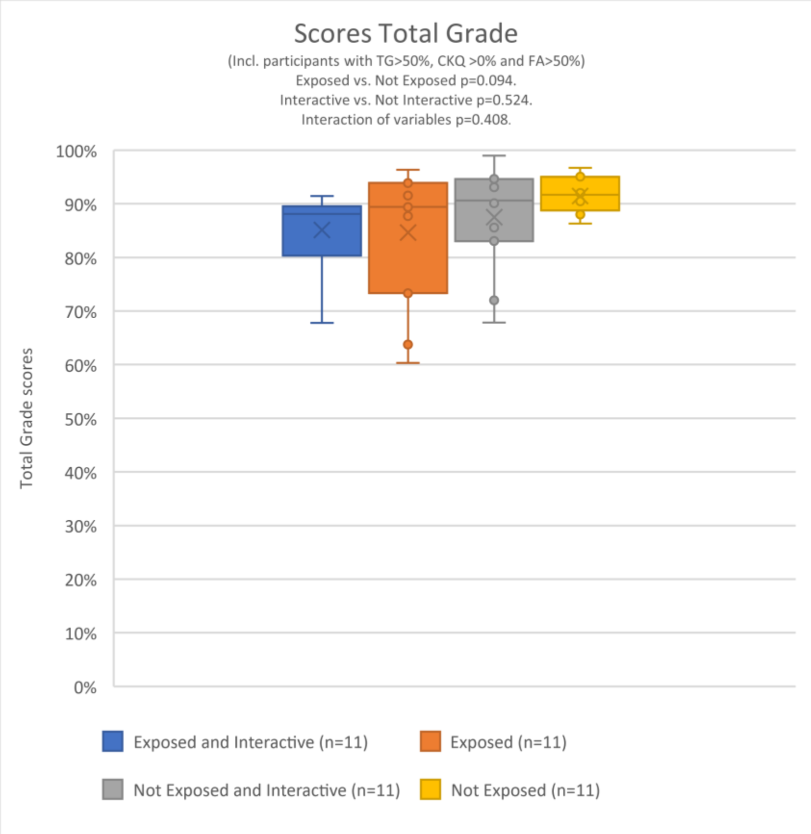



FIG. 4.20 Performance per cohort group of filtered data in boxplots, excluding all participants with a TG score <0%, CKQ score of 0% and a FA score <50%.

So in conclusion we can state the motivational incentives in the forms currently used had no significant impact on the improvement and performance of participants.

### 4.3.D Influence Cohort Groups on Completion Rate

This subsection will analyse the influence of the four different cohort groups on completion rates. Focus will be on the effect of the motivational incentives, however the influence of the second variable; interactive versus not interactive content, will also be considered. In this analysis all participants who have started the Pilot Course are included. It is assumed that all participants within this categorization have been exposed to the motivational video, if allocated to the Exposed Group, and the impact of the video can thus be measured from that group.

Figure 4.21 below illustrates completion rates of all four cohort groups. Two categorizations are visualized in the graph; in progress and finished. Definitions have been explained in Chapter 3, but will be briefly repeated here. With 'in progress' participants, reference is made to those who have started the Pilot Course, so have a score higher than 0% for the Knowledge Quiz, using corrected Knowledge Quiz Results, but have not completed the Pilot Course, so have a score of less than 50% for the Final Assessment. The category 'finished' contains all participants who have a score above 0% for the Knowledge Quiz and a score above 50% for the Final Assessment.

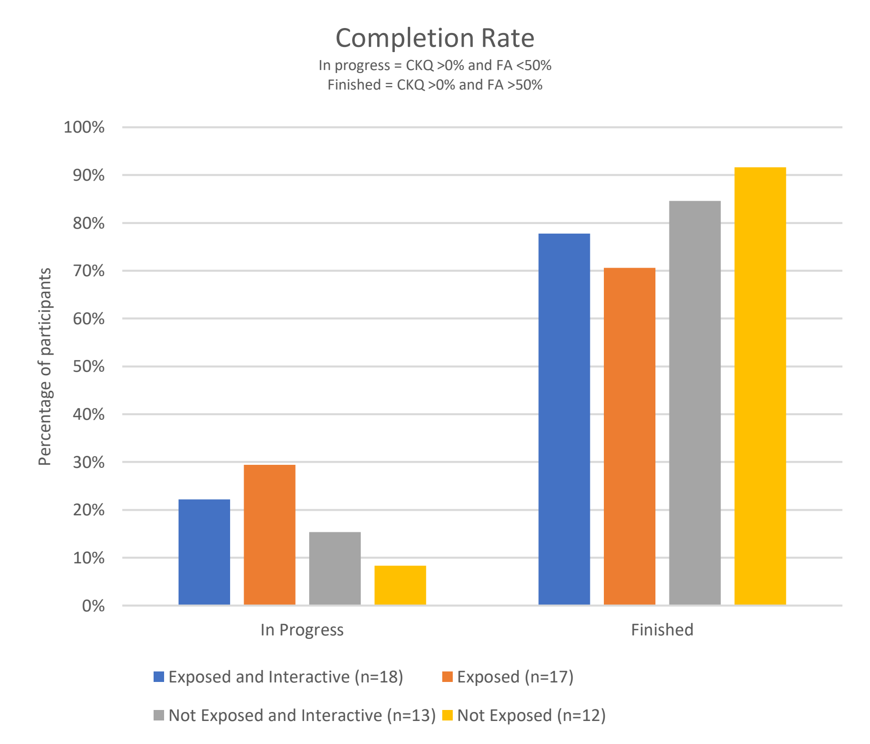



FIG. 4.21 Influence Cohort Groups on Completion Rate.

In Figure 4.21 we see that the Not Exposed Groups (both Not Exposed Interactive and Not Exposed not interactive) have higher completion rates. Participants exposed to the motivational incentives tend to not finalize the Pilot Course. Judging from the above given graph, there is no logical correlation between completion rates and interactive or non-interactive content. The overall completion rate of all four groups together is given below in Figure 4.22.

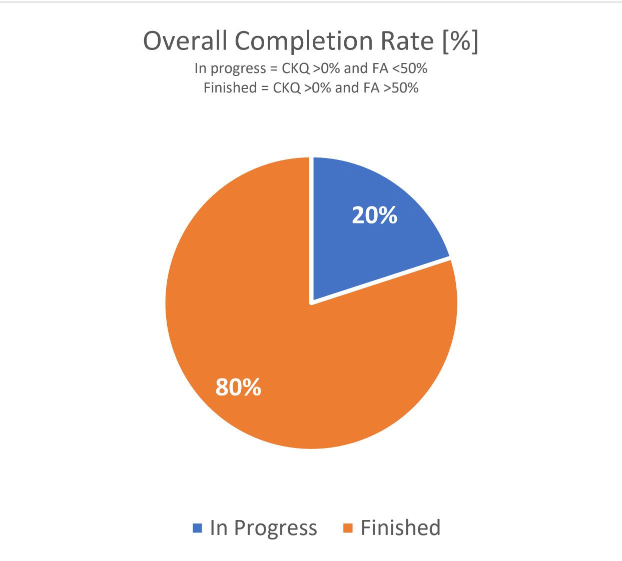



FIG. 4.22 Overall Completion Rate.

Completion rate can again be visualised by plotting histograms of all data, so including all participants who have initiated the Pilot Course; having a score of above 0% as Total Grade. Figure 4.23 below shows the histogram of all participants, not considering the impact of cohort groups. The numbers in the figure are absolute numbers, representing the number of participants within a column. The columns, so x-axis, show the Total Grade. The height of the columns illustrates the number of participants within that range for Total Grade scores. Participants with a Total Grade below 50% are considered as dropouts as explained in Chapter 3, so the left half of the graph shows all dropouts.

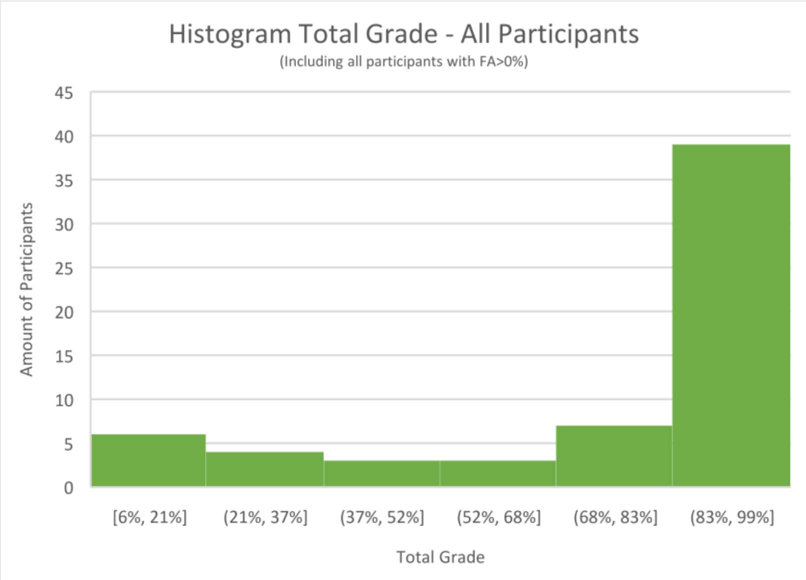
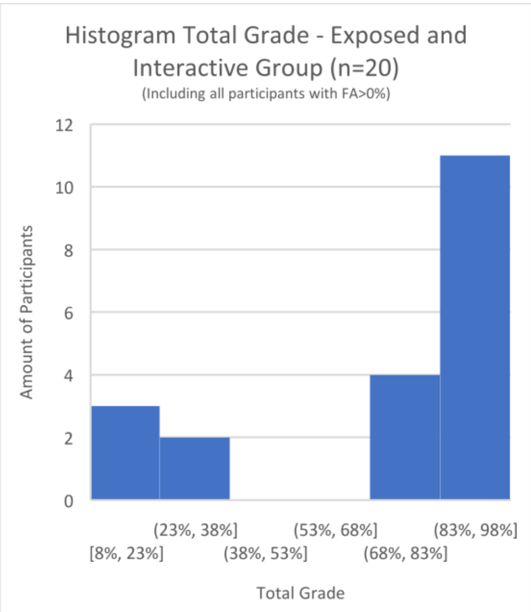



FIG. 4.23 Histogram illustrating completion rate of all participants (incl. all participants with FA>0%), Total Grade below 50% is considered as dropout.

The figures below illustrate the completion rates in histograms per cohort group. The Figures are split between the Interactive and Non-Interactive Group. So that the influence of the motivational incentives can be analysed. The first figure, Figure 4.24 illustrates the histograms of the Interactive Groups, with left the group exposed to the motivational incentives and right the group not exposed to the motivational incentives. Please be aware of the variation in group sizes and the therefore varying scales.



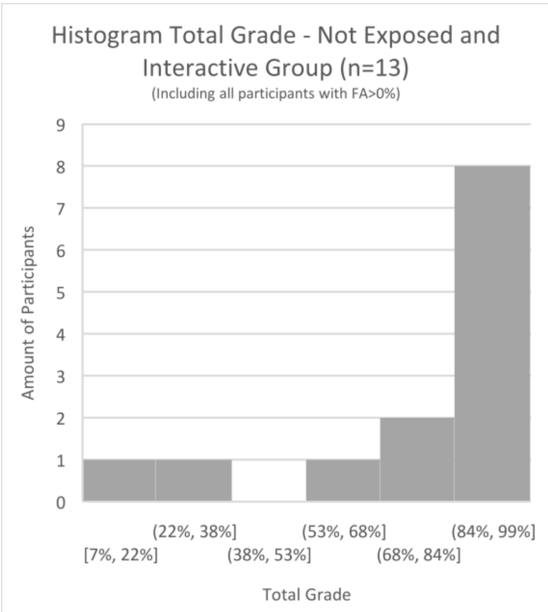




FIG. 4.24 Histogram illustrating completion rates of the group exposed to interactive content (incl. all participants with FA>0%), Total Grade below 50% is considered as dropout. Influence of motivational incentives is visualized.

The second figure, Figure 4.25 illustrates the histograms of the groups not exposed to interactive content, with left the group exposed to the motivational incentives and right the group not exposed to motivational incentives. Again please note the variation in group sizes and thereby variating scales.

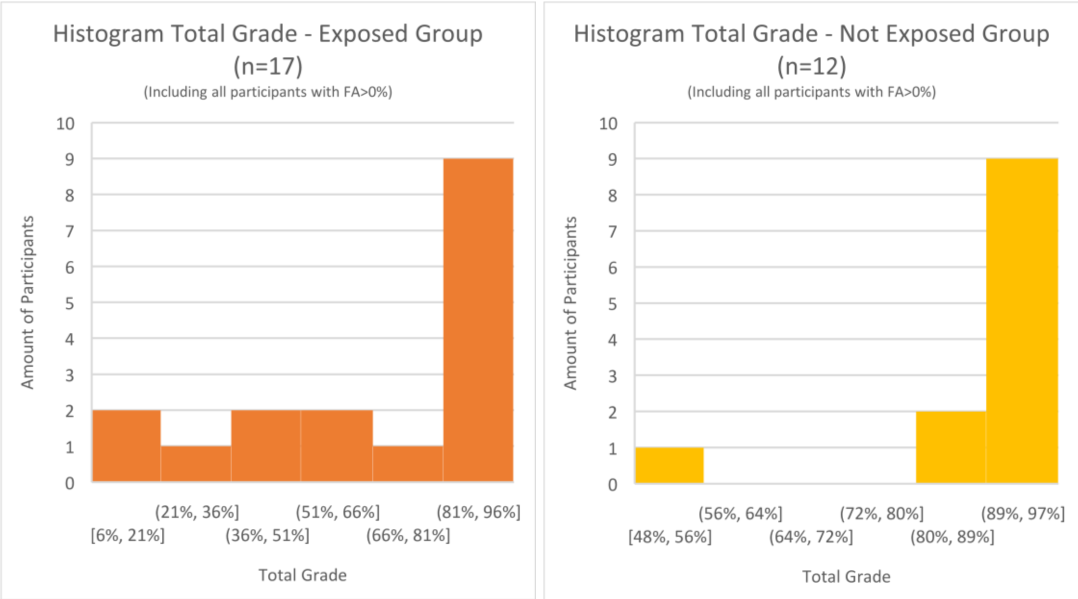



FIG. 4.25 Histogram illustrating completion rates of the group not exposed to interactive content (incl. all participants with FA>0%), Total Grade below 50% is considered as dropout. Influence of motivational incentives is visualized.

The charts above show that the completion rate among the Not Exposed (to motivational incentives) Group is higher and that no logical correlation between interactive content and completion rate can be found. So we can conclude the motivational incentives had a negative impact on completion rates.

### 4.3.E Characteristics of Participants influencing Improvement and Performance

Besides the influence of the different cohort groups, focused on the influence of motivational incentives, characteristics of participants might also have an influence on results found. This subsection will elaborate on relevant characteristics of participants found to show a relation to results.

The first important factor analysed is the location where participants are currently working and living. Data is analysed of participants who have finalized the complete Pilot Course only, so score for the Knowledge Quiz above 0% and score of the Final Assessment above 50%. Reasoning for this once again is to leave out dropouts, since that influences qualitative data incorrectly. Also only data from participants from South-East Asia and Africa are analysed and compared. Group sizes of other locations were too small to include. Figure 4.26[7] below illustrates all data of the two different regions summarized in improvement made by participants. No clear difference can be detected.

[7] In order to analyse the data, group sizes must be equal. Therefore all group sizes were set to an equal number of participants, where data points of additional participants were filtered based on moment of completion. So participants completing after the set total number of participants was reached were left out of this research analyses and are thus not visualized in this and following figures. As described in Chapter 3.

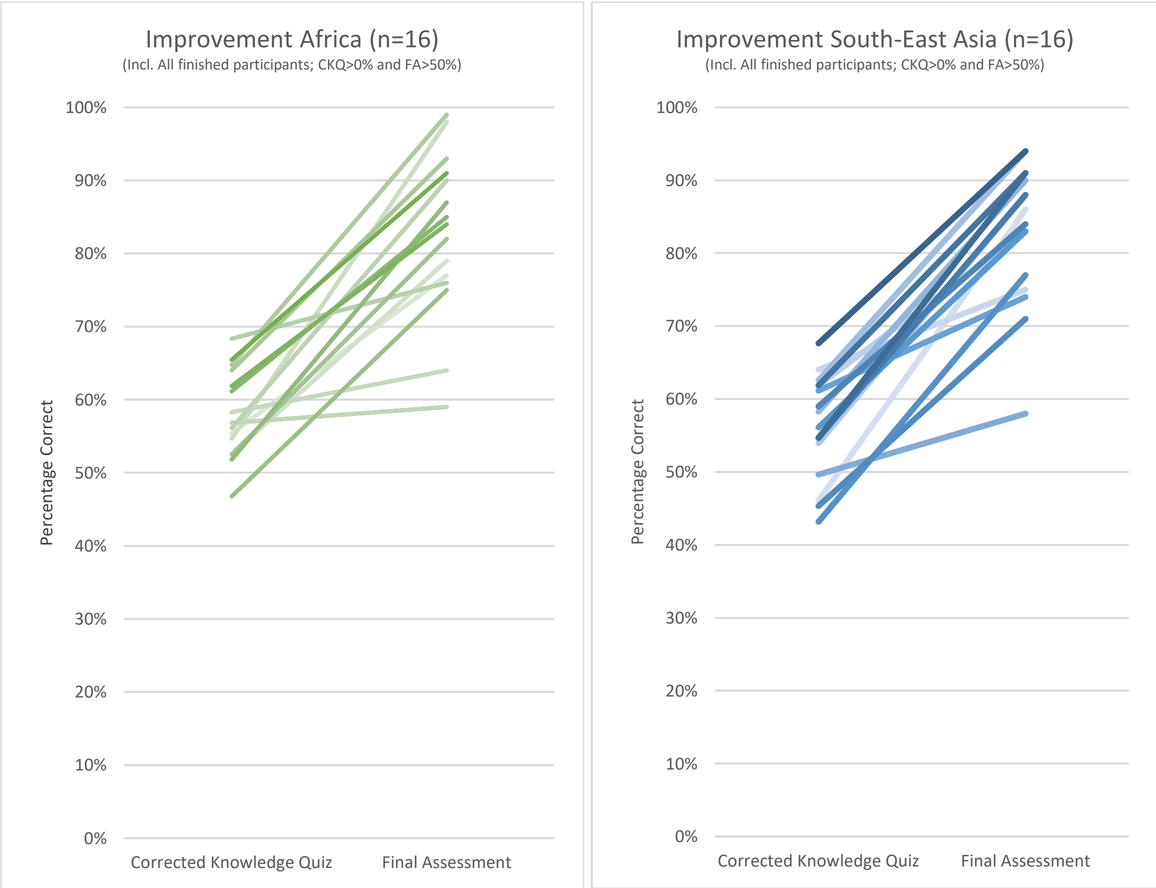



FIG. 4.26 Improvement of all participants, Africa compared to South-East Asia, not considering cohort groups. Excluding all participants with a TG score <50%, CKQ score of 0% and a FA score <50%.

The comparison between both regions is once again visualized in the boxplots given below in Figure 4.27. This figure illustrates the difference in performance, without taking cohort groups into account. Visible in the graph is that differences between the boxplots seem negligible. With a t-test it was examined if the difference can indeed be neglected. A p-value of 0.6167 was found, since this is higher than the alpha value of 0.05, we can conclude there is no significant difference in performance between these two regions, when not considering cohort groups. The reason for not analysing the impact of cohort groups is that the group size of each group is too small to draw conclusions for such an analysis.

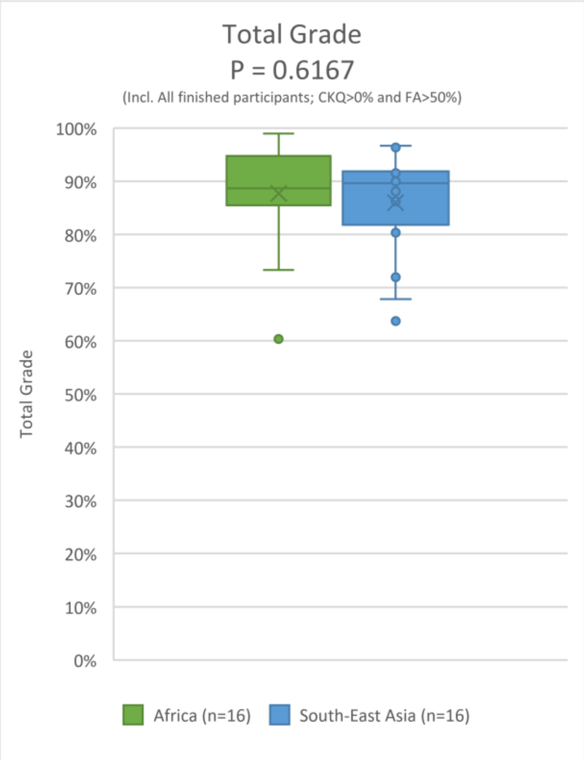



FIG. 4.27 Performance of all participants, Africa compared to South-East Asia, not considering cohort groups. Excluding all participants with a TG score <50%, CKQ score of 0% and a FA score <50%.

Figure 4.28 below illustrates the difference in completion rate between Africa and South-East Asia, once again without considering cohort groups due to small sample sizes. Visible is that participants from South-East Asia have a higher completion rate and participants from Africa tend to dropout faster.

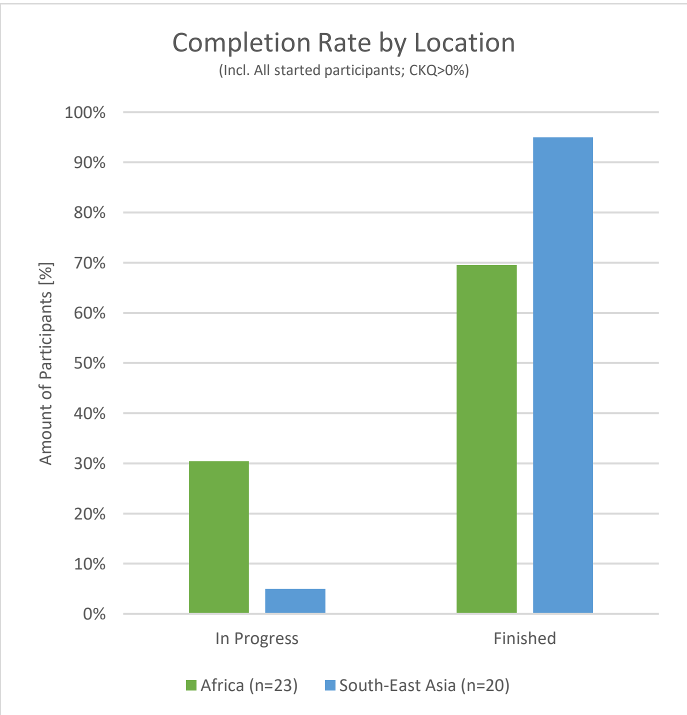



FIG. 4.28 Completion Rate of all participants, Africa compared to South-East Asia, not considering cohort groups. Excluding all participants with a CKQ score below 0%.

To illustrate some impact of cohort groups on the results by location, neglecting the small sample size, the figure below illustrates completion rate per region considering cohort groups. Figure 4.29 shows two graphs, one for participants from Africa and one for participants from South-East Asia, both illustrating completion rate per cohort group. Due to small sample sizes it is hard to draw conclusions. However, from the graph we learn that the difference in completion rate per region is probably not caused by the motivational incentives or interactive content. No logical relation can be found between the effect of the different cohort groups on completion rate and location.

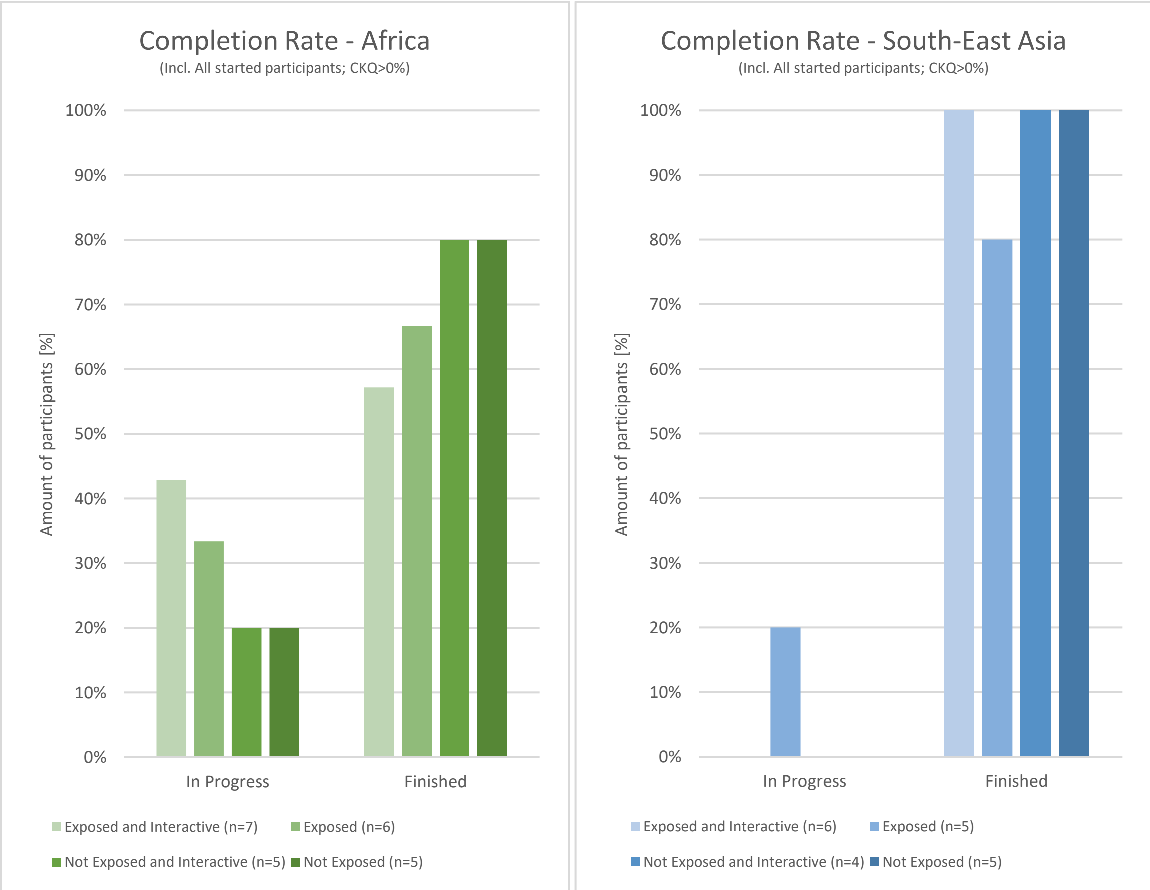



FIG. 4.29 Completion Rate per cohort group, Africa compared to South-East Asia. Excluding all participants with a CKQ score below 0%.

The second characteristic analysed is prior experience, Figure 4.30 below illustrates the effect of experience on performance. The experience visualized in the analyses is as follows; (1) I have not followed any training and have no experience with the Patient Monitor, (2) In the training I am following, we have not discussed the Patient Monitor yet, (3) I am currently discussing the Patient Monitor in the training I am following, (4) I have not followed any training, but I have worked with the Patient Monitor and (5) The Patient Monitor is discussed in a training I have followed. So the numbers represent a staircase of experiences; 1 meaning the least experience with the Patient Monitor and 5 is the category most experienced with the Patient Monitor. The left figure visualizes all data, however due to small sample sizes only the two most experienced groups are relevant. Therefore the right figure once again illustrates these specific groups. The difference between these groups is tested with a t-test, where it was found there is no significant difference in performance between these two groups. A p-value of 0.201 was found which is higher than the set alpha value of 0.05. The different cohort groups were not considered in this analysis due to too small sample sizes. Furthermore, all participants who have started the Pilot Course, so with a score above 0% for the Knowledge Quiz were considered.

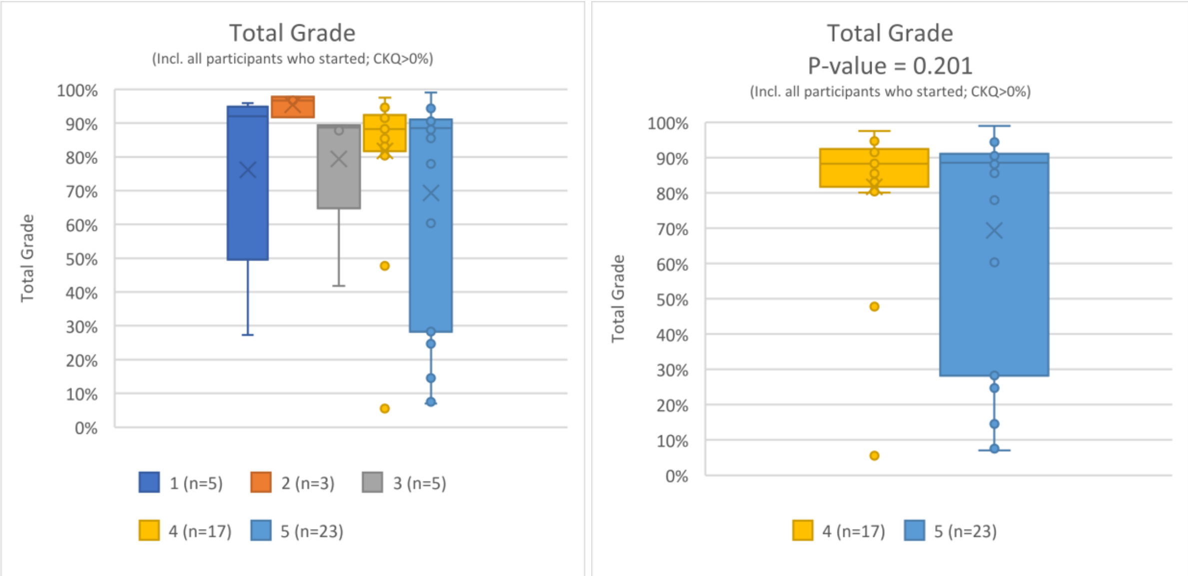



FIG. 4.30 Performance per experience, not considering cohort groups. Excluding all participants with a CKQ score below 0%.

Looking at profession, most interesting results can be found when analysing completion rates. Figure 4.31 below illustrates completion rates per profession, only considering participants who have started the Pilot Course. Participants with professions in a group size less than six participants were excluded, as conclusions cannot be drawn from such small groups. Visible in Figure 4.31 is that the completion rate is the highest for Biomedical Equipment Technicians currently working in a hospital. In the analysis cohort groups were not considered due to small sample sizes.

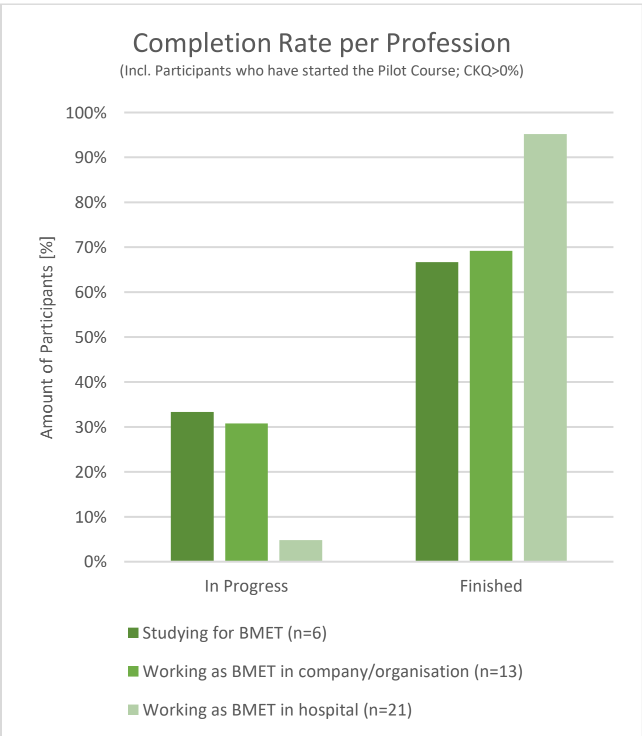



FIG. 4.31 Completion Rate by profession, not considering cohort groups. Excluding all participants with a CKQ score below 0% and professions groups containing less than six participants.

Completion rates are also analysed by age, which is visible in Figure 4.32 below. The group of participants within the age category 36-40 should not be considered, due to sample size. This group is visualized only to provide a complete data set. Visible in the graph is that no logical conclusion can be drawn from this figure. The highest completion rate lies within the group of participants with age 31-35, however no further logical relation can be found.

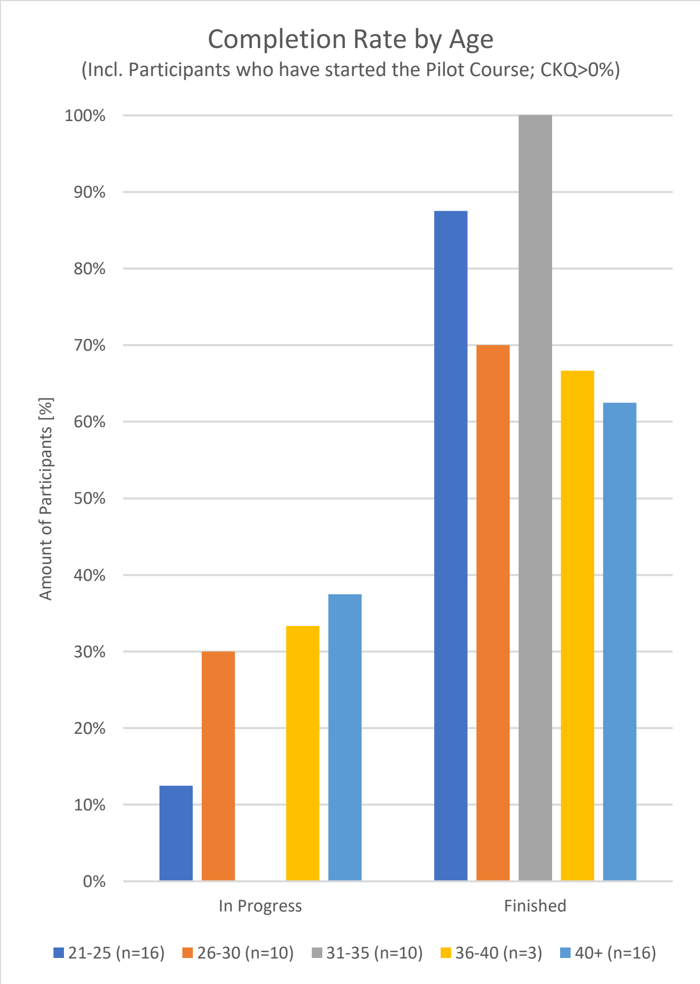



FIG. 4.32 Completion Rate by age, not considering cohort groups. Excluding all participants with a CKQ score below 0%.

### 4.3.F Other Influences or Trends

This subsection will analyse all other possible correlations or trends influencing results. Influences not caused by the added motivational incentives, the allocation of cohort groups and not by characteristics or experiences of participants. The first correlation sought, is the impact of time spent by the participants on the Pilot Course on performance. Figure 4.33 illustrates no correlation can be found between time spent on the Pilot Course, in hours, and the Total Grade achieved. Also the differences between cohort groups had no influence on this possible correlation. The Pearson product-moment correlation coefficient (R)[8], also shown in the figure, proves no correlation between Total Grade and time spent can be found. This applies to all four cohort groups. All four correlation coefficients found are approaching zero. The correlation coefficient found for Group A; Exposed and Interactive, is equal

[8] A Pearson product-moment correlation coefficient of 1 signifies a perfect positive correlation, equally a correlation coefficient of -1 signifies a perfect negative correlation. A correlation coefficient approaching zero means no correlation exists.

to 0.288. This is close to zero, so it can be concluded no correlation exists. The correlation coefficient found for Group B; Exposed, is equal to 0.003. This is approaching zero, so it can be concluded no correlation exists. The correlation coefficient found for Group C; Not Exposed and Interactive, is equal to -0.297. This value is close to zero, so it can again be concluded no correlation exists. The correlation coefficient of the last group, Group D; Not Exposed, is equal to -0.055. So also for the last group it can be concluded no correlation exists between Total Grade and time spent on the Pilot Course. Looking at all data together, the correlation coefficient is equal to 0.045, confirming the conclusion no correlation exists.

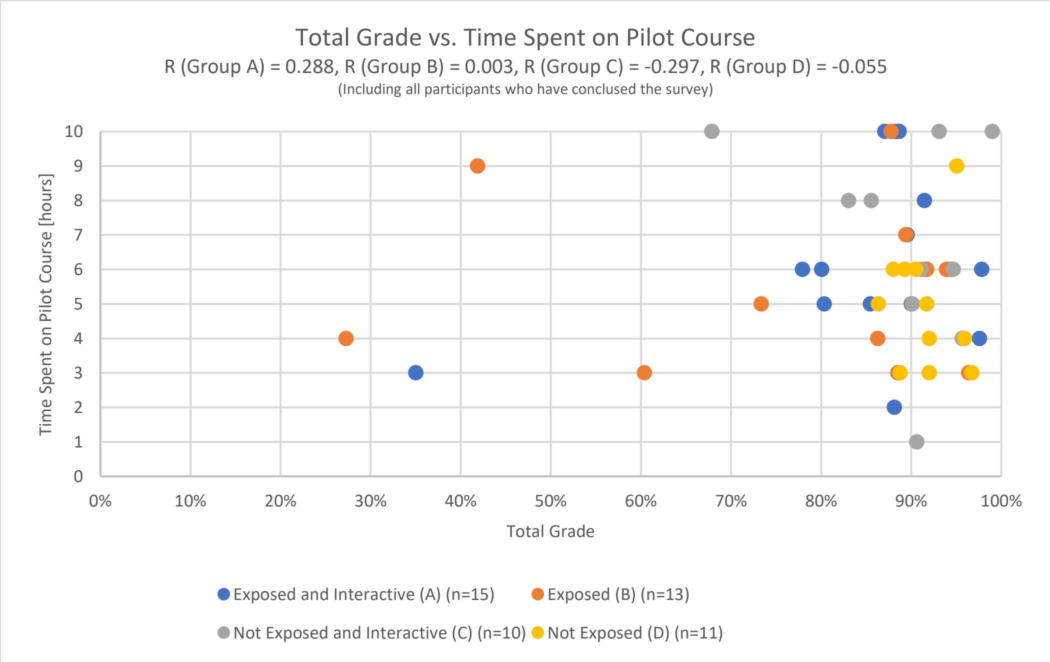



FIG. 4.33 Correlation between Total Grade and Time Spent on the Pilot Course, considering cohort groups. Excluding participants who have not completed the feedback survey.

The second possible correlation analysed is the correlation between Total Grade and overall rating of the Pilot Course assigned by participants. The effect of the different cohort groups was considered. Figure 4.34 below shows no correlation can be found between the overall rating given to the Pilot Course by participants and the Total Grade achieved. Also the different cohort groups had no influence on this possible correlation. The Pearson product-moment correlation coefficients (R), also given in the figure, proves no correlation between Total Grade and overall rating can be found. This applies to all four cohort groups. Three out of four correlation coefficients found are considered to be approaching zero. The correlation coefficient found for Group A; Exposed and Interactive, is equal to -0.091. The correlation coefficient found for Group B; Exposed, is equal to 0.305. The correlation coefficient found for Group C; Not Exposed and Interactive, is equal to -0.168. Only the correlation coefficient of the last group, Group D; Not Exposed, is equal to -0.509 and thus not close to zero. However the value is also not approaching -1, so no relation can be detected. Considering all other groups showed no correlation, this value is considered as not significant. So also for the last group it can be concluded no correlation exists between Total Grade and overall rating allocated by participants to the Pilot Course. Analysing all data together, the correlation coefficient is equal to 0.009 confirming the conclusion no correlation was found, since this value is approaching zero.

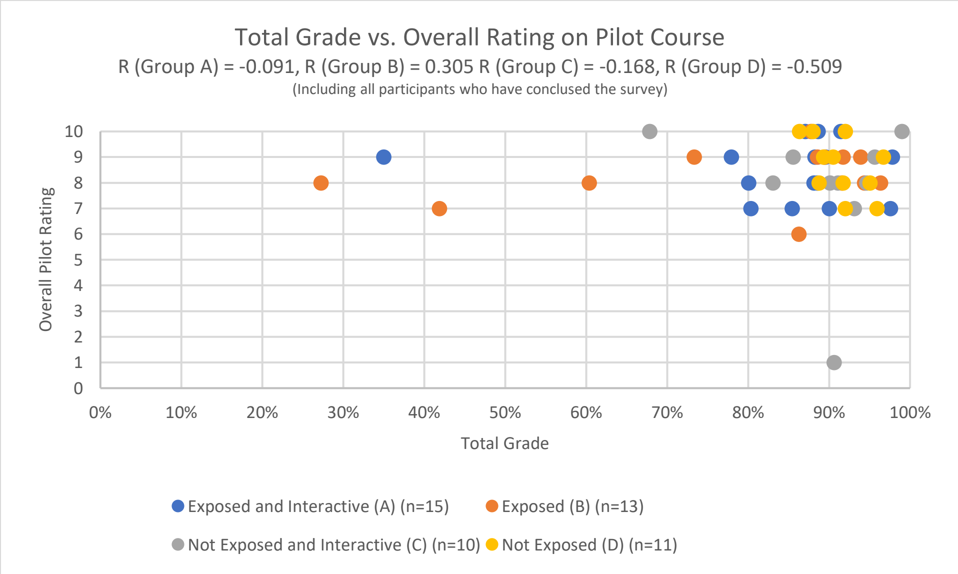



FIG. 4.34 Correlation between Total Grade and Overall Rating of the Pilot Course, considering cohort groups. Excluding participants who have not completed the feedback survey.

Technical aspects were also considered as possible influence on performance or improvement. The figures below illustrate possible correlations, between potential technical hurdles and performance. The first potential hurdle is internet reliability; it might be assumed that low internet reliability negatively influences performance made throughout the course. Figure 4.35 below illustrates the correlation between internet reliability and Total Grade. The figure also illustrates the difference between the different cohort groups. It can be concluded that hardly any correlation can be found between internet reliability and the Total Grade achieved. The Pearson product-moment correlation coefficient (R), also given in the figure, proves hardly any correlation between Total Grade and internet reliability can be found. Three out of four correlation coefficients found are considered to be approaching zero. The correlation coefficient found for Group A; Exposed and Interactive, is equal to -0.166. The correlation coefficient found for Group B; Exposed, is equal to -0.354. The correlation coefficient found for Group C; Not Exposed and Interactive, is equal to 0.408. The correlation coefficient of the last group, Group D; Not Exposed, is equal to 0.616. This value must be considered as approaching 1, so approaching a perfect positive correlation. Therefore it can be concluded for the Not Exposed group that the Total Grade is higher when the internet reliability is better. Analysing all data, so all cohort groups together, the correlation coefficient found is equal to -0.008. Since this value is approaching zero, it must be concluded no overall correlation is found between internet reliability and Total Grade.

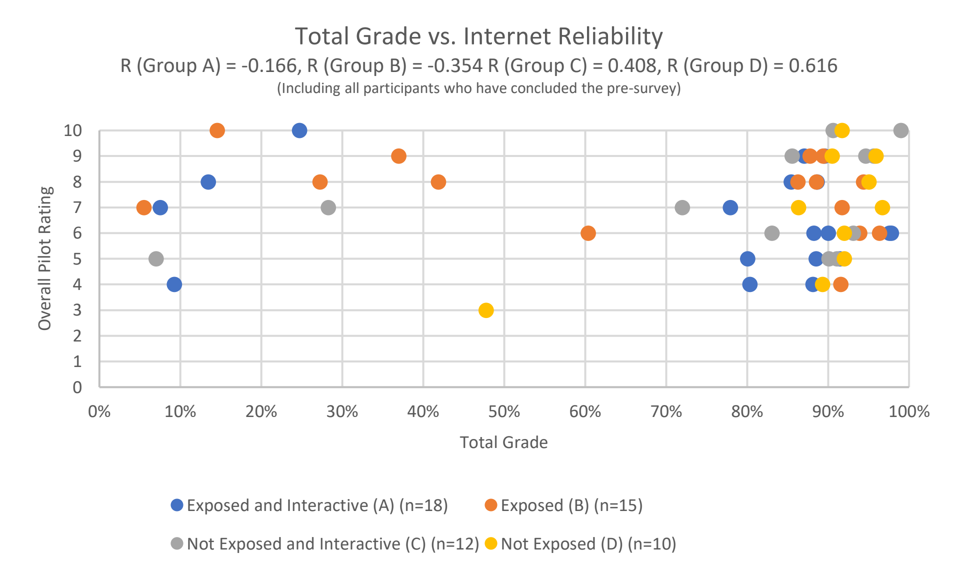



FIG. 4.35 Correlation between Total Grade and internet reliability, considering cohort groups. Excluding participants who have not completed the pre-survey.

Another potential hurdle is the device used to complete the Pilot Course. Figure 4.36[9] illustrates the different performance per device type. Included in the figure are all participants who have started the Pilot Course. Reasoning for not filtering out dropouts is that device related hurdles might be the cause for not completing the Pilot Course. A t-test was performed to statistically test whether a difference could be detected. The found p-value of 0.975 concludes no significant difference is detected. So no significant hurdle could be detected from medium used.

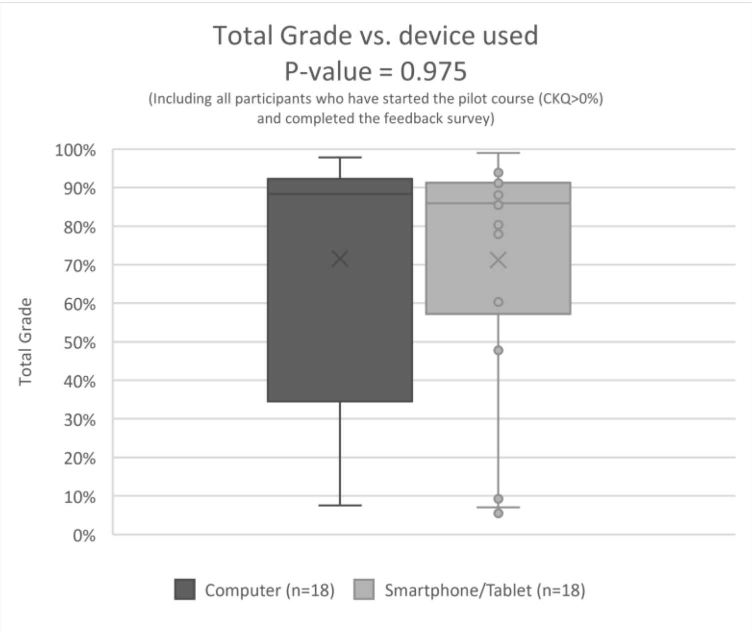



FIG. 4.36 Performance visualized per possible device used to complete the Pilot Course, not considering cohort groups. Excluding participants who have not completed the feedback survey and only including participants who have started the Pilot Course (CKQ>0%).

[9] In order to analyse the data, group sizes must be equal. Therefore all group sizes were set to an equal number of participants, where data points of additional participants were filtered based on moment of completion. So participants completing after the set total number of participants was reached were left out of this research analyses and are thus not visualized in this and following figures. As described in Chapter 3.

## 4.4. Design and setup of an online BMET Training or MOOC

In the several surveys completed by participants, data was collected relevant to the research question and hypothesis. In addition, the surveys requested input regarding the design, setup and content of the final MOOC, this section will elaborate on results on that topic.

First relevant data was collected via the Pre-Survey, requested to be completed at the beginning of the Pilot Course. In this survey, expectations were questioned, before being influenced by the setup of the Pilot Course. Figure 4.37 below illustrates what is important for participants to enrol in a course. Nine different possible aspects of a course were questioned; (1) Potential usefulness of this course in my studies and/or career, (2) Future perspectives offered/made possible by following the course, (3) Interesting topic of the course, (4) That the course is offered online, (5) Universities involved in this course, (6) Duration of the course, (7) Pace and flexibility offered in participating in the course, (8) Language and translation possibilities and (9) Possibilities of receiving a certificate or credentials for this course. Visible in the figure is that all nine characteristics are rated important. Most relevant four are the potential usefulness of the course in studies or career, number 1, the pace and flexibility offered, number 7, language and translation options, number 8, and receiving a certificate, number 9. However, if possible, respondents give preference to all nine possibilities proposed.

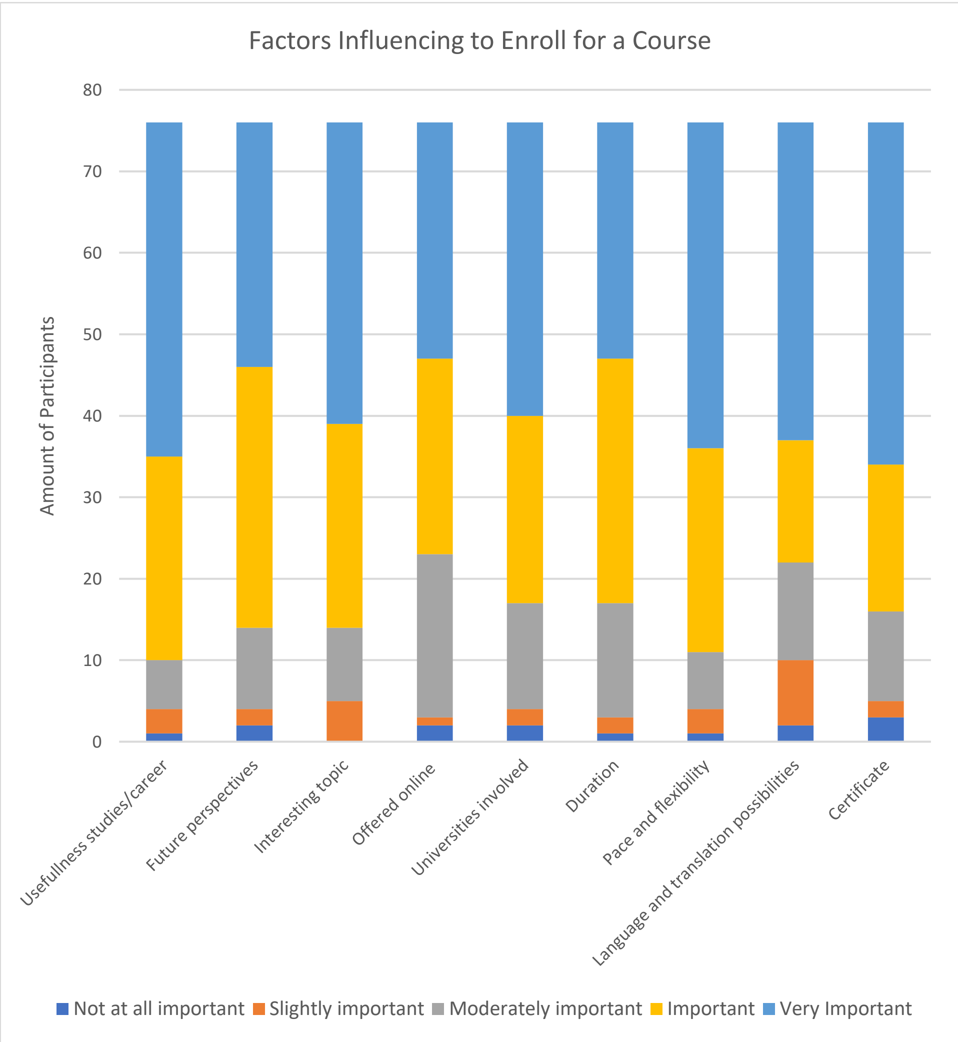



FIG. 4.37 Characteristics of the course important for participants to enrol.

After rating 'Pace and flexibility offered in participating in the course' mostly as very important, one might wonder what the desired pace is. Figure 4.38 below illustrates expectations are widely varied, so conclusions cannot be drawn from this.

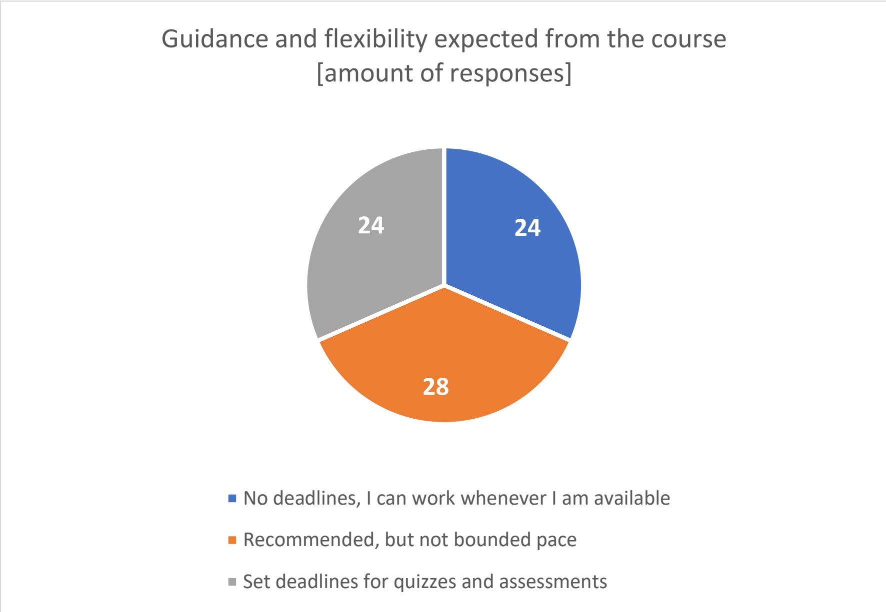



FIG. 4.38 Guidance and flexibility expected from the course. Numbers are absolute numbers and represent responses to the question, so absolute number of participants.

Respondents were asked what they hope to gain by participating in this course, the three most common answer types were; gaining in depth knowledge and understanding of the Patient Monitor, medical equipment in general and the role of a BMET, so in other words; be educated to become a BMET. In addition, respondents replied they hope to improve practical skills. Lastly, the largest group replied they hope to improve and refresh knowledge. So in summary an important combination of new knowledge, refresh and upgrade knowledge and specifically gain practical skills. Some other, due to low frequency less relevant, responses were to receive a certificate and to build a network online.

The second relevant survey analysed is the feedback survey. In this survey participants were requested to give feedback on the design, setup and content of the Pilot Course and to share insights and experiences. General feedback was requested, which is summarized in Figure 4.39 and 4.40 below. Figure 4.39 illustrates how participants rate the design and look and feel of the Pilot Course. They were informed the Pilot Course is only a pilot, so developed with its limitations. Visible is that more than half of the participants rated the design and look and feel of the Pilot Course with a grade of above 8 on a scale of 1 till 10. The average rating for design and look and feel of all participants is an 8.2.

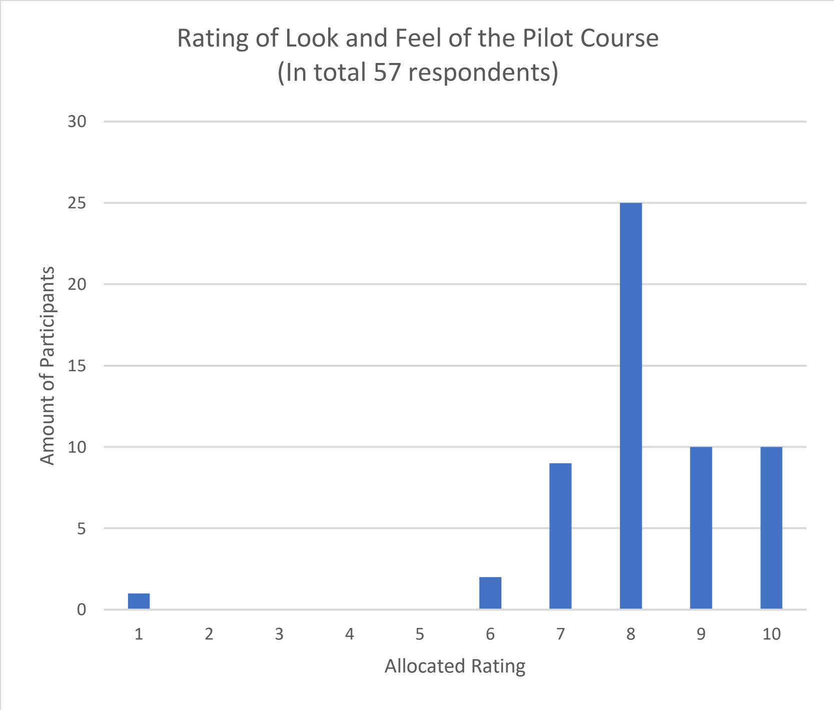



FIG. 4.39 Participants rating for the Design and Look and Feel of the Pilot Course. Rating on a scale from 1-10.

Figure 4.40 below illustrates participants overall rating for the Pilot Course. The figure can be summarized with an average score of 8.3. One extreme outlier is visible in the figure, rating the Pilot Course with a 1. This participant was not satisfied with the setup of the course, but was not willing to elaborate further on how the course could be improved. This score will be considered as an exception and not considered any further.

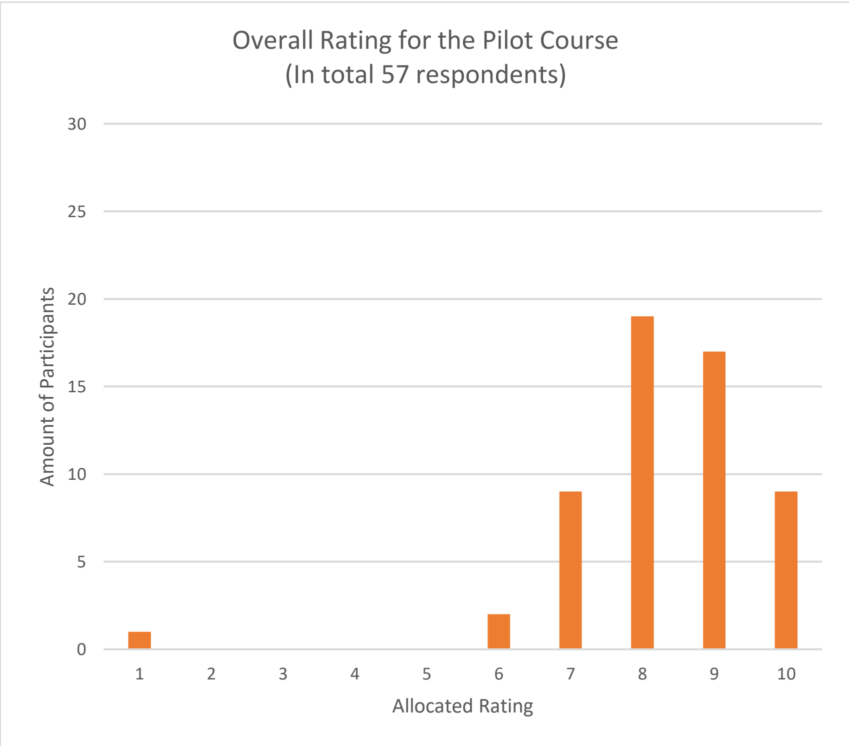



FIG. 4.40 Participants overall rating for the Pilot Course. Rating on a scale from 1-10.

Participants were asked if they experienced any technical limitations whilst completing the Pilot Course. 75% Of the participants indicated they indeed experienced some form of technical limitation. Most common and relevant explanations to those limitations were; spelling errors in computer verified open questions. The limitations participants are referring to is that if they make spelling errors or add additional information to responses for open questions, the computer will revise their answer as incorrect. This could be adjusted manually, but is misleading to participants and requires a lot of manual work if the course would be made available to everyone interested. So this is important to take into consideration when designing the final MOOC. The second common mentioned error was experienced with the drag and drop questions, when completing the Pilot Course on a smartphone or tablet, these questions caused technical limitations. This could be prevented by using the application, which however is not possible when using edX Edge. If using drag and drop exercises in the MOOC, instructions should specifically mention exercises are only suitable for computer use or via the application. The last limitation was caused by language, English gave an extra challenge to some of the participants. Ideally, the final MOOC has translation possibilities to multiple languages. Languages requested by participants for translation possibilities were Spanish and French. The questions themselves were judged to be clear; more than half of the participants stated questions were clearly formulated.

Participants were also asked what the most valuable part within this Pilot Course was to them. Specific topics most mentioned where troubleshooting, overlapping slightly with the preventive maintenance section. Also the physiology and engineering section was often mentioned. More general aspects most valuable to participants, were the exercises positioned directly after theory, forcing them to apply knowledge. The short videos were experienced as very clear, short and fun. Also the BMET library was often used and highly appreciated, it provided an opportunity for extended learning and educated participants on how to find information.

On top of asking for positive feedback, participants were also asked what elements of the Pilot Course could be improved. The most common feedback was to add a legend or overview throughout the material. Modules seemed to be overlapping, no clear distinction was given when going from the first to the second module. The second most common feedback given was the request for more videos, with as clear focus the more practical topics. In addition real life examples or case studies are requested. Also, some participants mentioned they thought the Pilot Course was too extensive and thus required too much time to complete.

Below, in Figure 4.41, participants rated the Pilot Course on three qualities. The figure shows the Pilot Course was perceived mostly as useful, but also as unique and interesting. Almost all participants agreed with the allocation of these terms to the Pilot Course.

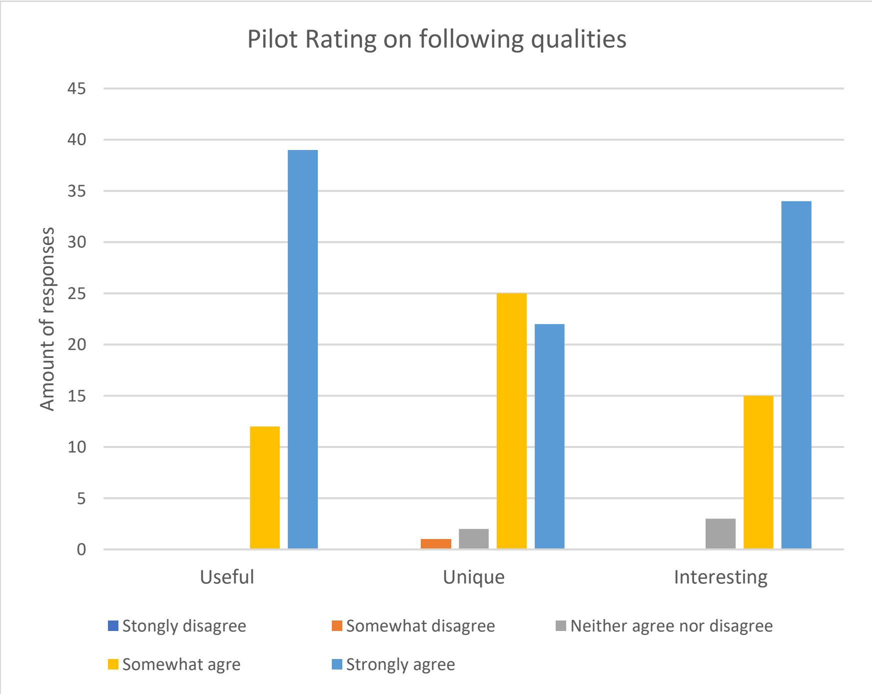



FIG. 4.41 Participants opinion on allocating qualities to the Pilot Course.

Visible from Figure 4.42 below is that the level of difficulty compared to other existing training programs is about right. 20% Of all participants indicated the Pilot Course is too easy or even far too easy, however participants of the Pilot Course were relatively high educated and experienced. The final MOOC is aimed at less experienced participants, at least Course 1 and 2. So concluding from Figure 4.42 below, the level of the Pilot Course was about right.

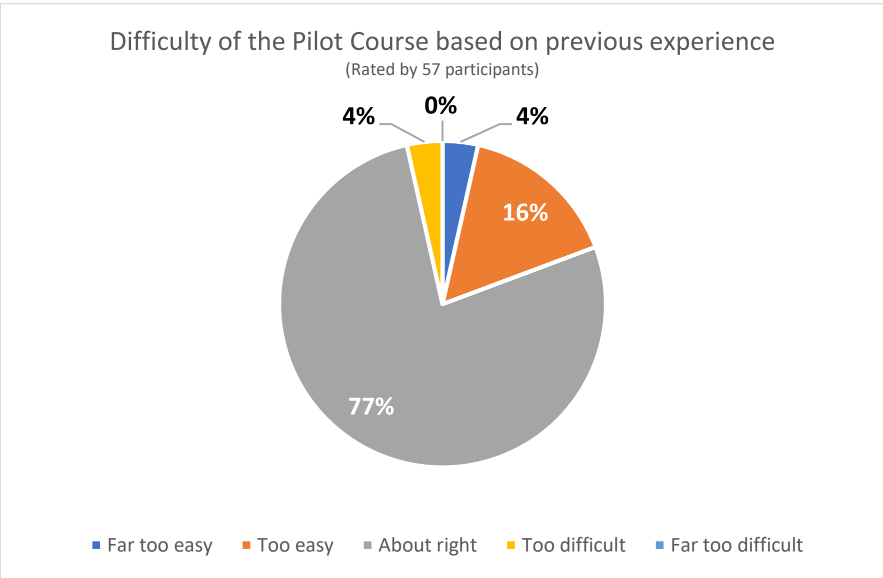



FIG. 4.42 Level of difficulty of the Pilot Course, judged by participants in the Feedback Survey.

Concluding from Figure 4.43 below, the amount of work required for the Pilot Course was also about right. A small group judged too much work was required to complete the Pilot Course, which is in line with previous shared feedback that some participants requested the Pilot Course to have a shorter duration. An explanation for this can be that the Pilot Course included two surveys, which the final

MOOC will not have. In addition, the Pilot Course contained a general introduction, a knowledge quiz and a final assessment. The final MOOC will not contain all those sections per device or sub section, automatically making each sub section of the final MOOC shorter compared to the Pilot Course. 9% Evaluated too little, or even far too little work was required to complete the Pilot Course. This could be caused by the fact that they answer this question as if it is a complete MOOC educating them to become a BMET.

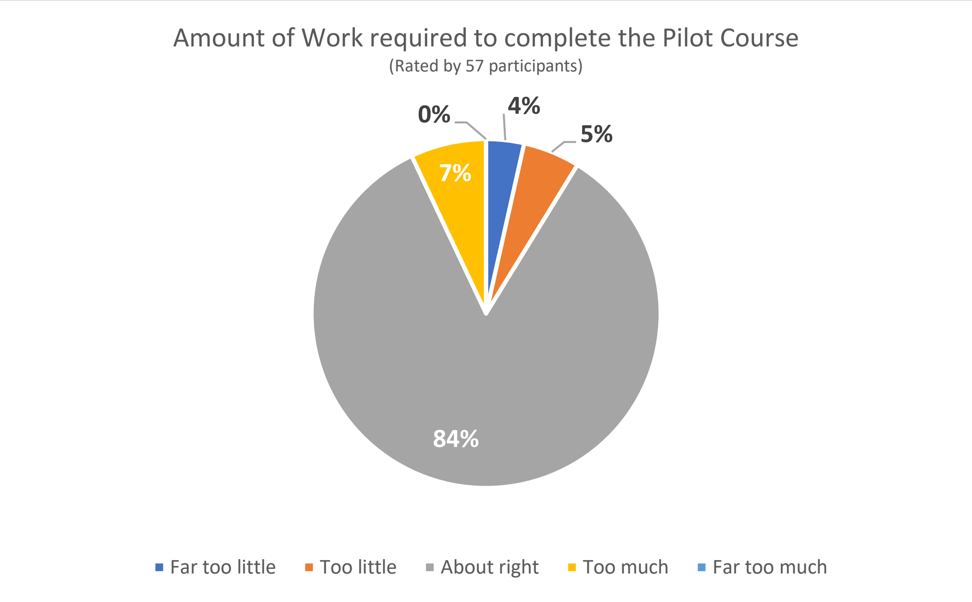
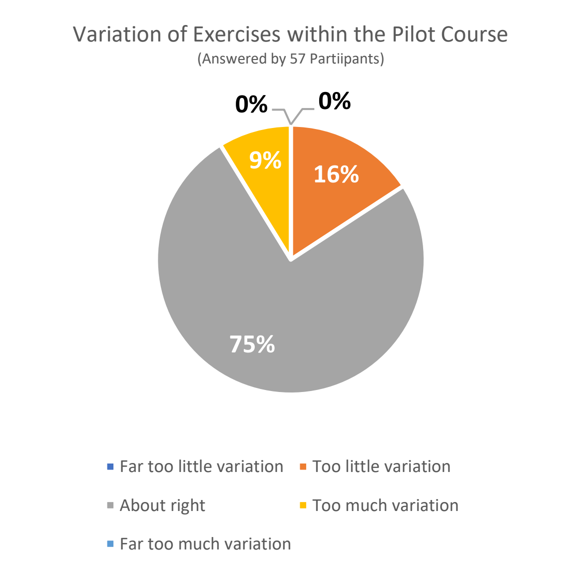



FIG. 4.43 Amount of work required to complete the Pilot Course, judged by participants in the Feedback Survey.

Participants were also asked what exercise type they liked best, where both regular multiple choice and the drag and drop questions scored most popular. The drag and drop questions do require the side note that participants completing the Pilot Course by smartphone or tablet experienced technical limitations with these questions. Reasoning for the popularity of the drag and drop questions is that it was experienced as more fun. In addition participants stated the drag and drop questions were a suitable manner to test practical knowledge. Multiple Choice was often chosen since these questions were most clear and relatively easy to answer which appealed to most participants. On top of that one could imagine that both drag and drop questions as well as multiple choice have the benefit of overcoming spelling issues in a foreign language.

Figure 4.44 below answers general feedback questions within the Pilot Course. From the figure it can be concluded that participants like to see variation in questions; the majority of the participants from the Pilot Course rated variation was about right. In addition the figure implies participants like to have exercises in addition to theory. Again the majority rated the amount of exercises compared to theory within the Pilot Course to be about right. An explanation for some variation in responses is that there was a second research running on this Pilot Course[10]. Because of this half of the participants were exposed to more questions compared to theory than the other half of the participants. As the question regarding amount of exercises was added slightly later, we do observe some variation in the amount of responses to this very question compared to other questions.

[10] Research performed by Daniel Garcia de las Heras; 'Fundamentals for the Design of a MOOC to train Biomedical Equipment Technicians in LMIC'.



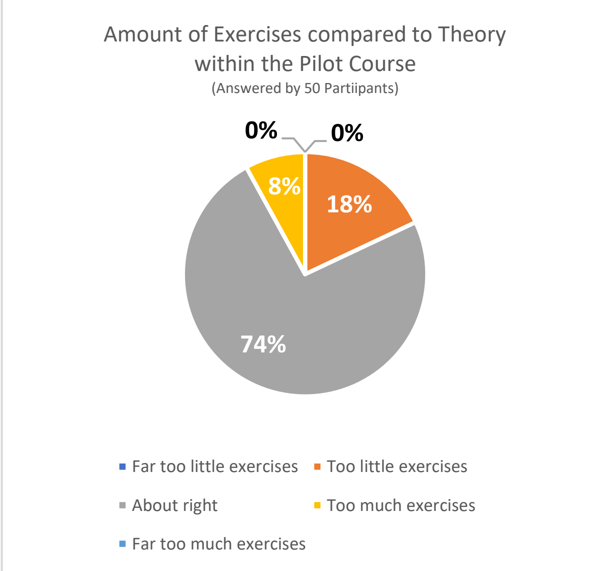




FIG. 4.44 General feedback on questions within the Pilot Course, judged by participants in the Feedback Survey.

The feedback survey also requested input for the final MOOC. The figure below, Figure 4.45, illustrates the preference for a self-paced course over an instructor-paced course. This question was asked after completion of the Pilot Course, which was self-paced and thus might have caused some bias towards these responses. Also, as the difference is very small, the recommendation following from this result is not leading to different insights.

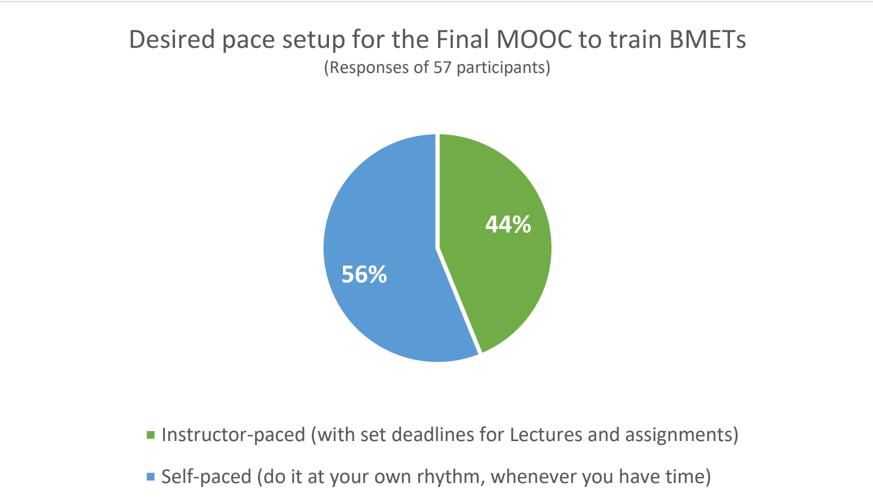



FIG. 4.45 Desired pace of participants for the final MOOC, judged by participants in the Feedback Survey.

Finally, participants were asked how their job as a BMET in LMIC could be improved, implying participants have working experience or knowledge of current issues. Figure 4.46 illustrates most common challenges BMETs are currently experiencing in repairing out of service medical and laboratory equipment. The most common challenge is lack of spare parts and consumables. Spare parts or consumables cannot be provided by an online training, however, the training could be designed in such way that participants are educated to creatively solve these issues. Literature indicated 65% of all reported out of service medical and laboratory equipment can be solved with current material [2]. The training however, must educate potential BMETs how to perform the repair with the limited supplies. The second biggest challenge mentioned is lack of knowledge and information. This challenge can definitely be solved with the creation of an online BMET training. Adding a BMET library in the training and providing participants with a network, will allow them to find or request further information after completion of the training as well.

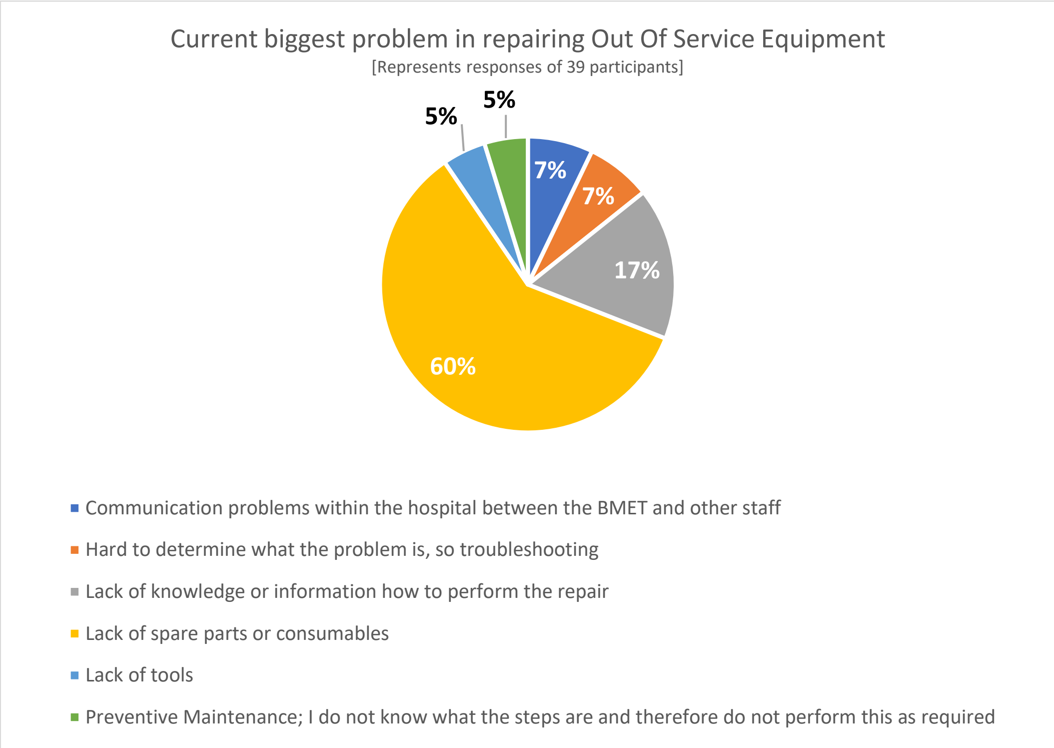



FIG. 4.46 Current challenges in repairing out of service medical and laboratory equipment, responses of 39 participants from the Feedback Survey.

In addition to the above given figure, the question was asked what could improve their job as a BMET. Most common response was training, either a more extended training or continuous training. Another common reply was a library or platform providing useful documents and manners of finding information, which could be provided within the MOOC by implementing something similar to the BMET library as included in the Pilot Course.

# 5

# Discussion

Before being able to draw conclusions, we must analyse the most relevant results and acknowledge limitations from this research. This section will elaborate on interpretations of results and sum up limitations of this research, whilst analysing possible improvements.

## 5.1. Interpretation of Results

When analysing results, most relevant findings refer to the hypothesis and research question. Let us first recall the hypothesis; *'Biomedical Equipment Technicians can be educated with the required knowledge level and set of skills via a MOOC, in addition results of participants and completion rate among participants will increase when being exposed to motivational incentives, where no other characteristics influencing results can be found.'* In other words, the hypothesis states that it is possible to train Biomedical Equipment Technicians with the required set of skills and knowledge. In addition the hypothesis states that the group being exposed to the motivational incentives is expected to both perform better in the Pilot Course and have a higher completion rate in the Pilot Course. Lastly, the hypothesis states no other characteristics of participants influence results. Let us first look at the first two parts of the hypothesis. These results were visualized in Figure 4.19 'Improvement per cohort group of filtered data in boxplots, excluding all participants with a TG score <0%, CKQ score of 0% and a FA score <50%.', Figure 4.20 'Performance per cohort group of filtered data in boxplots, excluding all participants with a TG score <0%, CKQ score of 0% and a FA score <50%.' and Figure 4.21 'Influence Cohort Groups on Completion Rate.'

Let us first analyse whether indeed the required set of skills and knowledge could be educated via an online training. Analysing both Figure 4.19 and 4.20, we see median results for both the Final Assessment and the Total Grade are above 80% for all cohort groups. These results compared to the results for the Knowledge Quiz, whilst analysing the corrected Knowledge Quiz results, of approximately 60% for the medians of all cohort groups, we can conclude sufficient improvement is made. Thereby the first part of the hypothesis; *'Biomedical Equipment Technicians can be educated with the required knowledge and set of skills via a MOOC'* seems to be confirmed. Based on results we can confirm participants have been educated with the knowledge and skills they have been exposed to within the Pilot Course. However, within the scope of this research we cannot conclude participants are educated with the required set of skills and knowledge. This conclusion can only be drawn after verifying results in practice. So further research must be done to analyse whether the knowledge level and set of skills acquired within this Pilot Course is indeed the required knowledge level and set of skills to become a BMET. In addition, whilst building from this conclusion, one must include recommendations with regards to the design of an online training or MOOC. Recommendations are based on results found in the last section of the previous chapter and will be discussed in the next chapter. To summarize, Biomedical Equipment Technicians can be educated via an online training or MOOC, when designing according the provided recommendations and whilst considering it has not been proven yet the acquired level is as required.

In order to verify the second part of the hypothesis, stating the group exposed to the motivational incentives will perform better in the Pilot Course, so have higher grades and a higher completion rate, we must analyse Figures 4.19, 4.20 and 4.21 and the results of the statistical tests. There we find no significant difference is found between the different cohort groups for performance and improvement. From this we can conclude that the differences are not significant and thus that this research has not been able to prove that the motivational incentives, in the forms currently used, had a positive or negative impact on performance and improvement.

Let us now look at Figure 4.21, mapping the completion rates. We can see in that figure that the completion rate among the Not Exposed Group is higher, compared to the Exposed Group. No logical relation to interactive versus not interactive content can be found. The figure illustrates that the Exposed Group tends to not complete the Pilot Course and thus has a higher dropout rate. So in conclusion this research has not been able to prove the motivational incentives, in the forms currently used, had a positive impact on completion rate. Therefore the second part of the hypothesis must be rejected.

The question remains why the motivational incentives, in the forms currently used, show no proven impact on performance and a negative impact on completion rate within this Pilot Course. The most important reason is the audience reached within this research. Analysing the participants and their current situation and background, it can be concluded this group was already aware of the problem. Many participants are currently working as BMET in a hospital or company experiencing the large number of medical and laboratory equipment reported as out of service. In addition, one must realize participating in this Pilot Course was time and effort consuming and thereby required motivation. On average participants spent six hours to complete this Pilot Course, which was completely voluntary without any rewards or benefits. Whilst realizing this, one can conclude this research was biased from the beginning; the group of participants this research had to cope with was already intrinsically motivated before being exposed to the additional motivational incentives.

In addition to analyse the hypothesis, results answering sub questions must also be understood and interpreted. The sub question not yet discussed, corresponding to the last part of the hypothesis is ‘Are the results achieved within this research influenced by characteristics or qualities of the participants?’ The first characteristic analysed on possible effects on the results within this Pilot Course was location. In order to verify if location and thus culture indeed had an influence on results, we must analyse Figure 4.27 ‘Performance of all participants, Africa compared to South-East Asia, not considering cohort groups. Excluding all participants with a TG score <50%, CKQ score of 0% and a FA score <50%’. We can see in that figure that there is no significant difference in performance between participants from Africa versus South-East Asia. The statistical test confirms this observation, so we must conclude location had no influence on performance.

Completion rate on the other hand did show a difference, which is visible in Figure 4.28 ‘Completion Rate of all participants, Africa compared to South-East Asia, not considering cohort groups. Excluding all participants with a CKQ score below 0%’. It can be seen that the completion rate is higher among participants of South-East Asia. African participants tend to dropout. This can be explained by looking at the cultural differences between both regions. It is stated that members of individualistic cultures focus on success, where collective cultures tend to focus on prevention, or avoiding failure [22]. Both Africa and South-East Asia can be considered as collective cultures, meaning they will be avoiding failure. This tendency to avoid failure might lead to not completing the Pilot Course; not completing limits the possibility to fail. However, both regions are considered a collective culture so that cannot be the main cause for this result. There are two other possible reasons causing the higher completion rate among South-East Asian participants; first of all the motivational incentives. These incentives were created by and for people from South-East Asia, this might have stimulated this group to finalize the Pilot Course. However, from Figure 4.29 ‘Completion Rate per cohort group, Africa compared to South-East Asia. Excluding all participants with a CKQ score below 0%’, it becomes clear that exposure to the motivational incentives did not have relevant influence on completion rates for neither African participants nor participants from South-East Asia. Therefore the second possibility is the most plausible cause; the propensity to stick to discipline coherent to the Asian culture [23].

Other characteristics of participants influencing results are prior experience and profession. Let us first look at prior experience, which is illustrated by Figure 4.30 ‘Performance per experience, not considering cohort groups. Excluding all participants with a CKQ score below 0%’. Unfortunately group sizes differ, making these results less relevant. Therefore only the two most experienced groups are considered; (4) I have not followed any training, but I have worked with the Patient Monitor and (5) The Patient Monitor is discussed in a training I have followed. The right part of Figure 4.30 illustrates no significant difference can be found between these two categorisations. It was assumed that Group 5 would have the highest Total Grade, due to pre knowledge, but this is not the case. In contrary, the graph shows us that Group 2 has the highest Total Grade; the group currently in training, but without any experience or knowledge from the Patient Monitor. The reason for these unexpected results can be found in focus and motivation. Participants in training, but without any experience or knowledge from the Patient Monitor are relatively highly interested in acquiring knowledge. The experienced group on the other hand is less interested since knowledge is assumed to be mastered already. Therefore the more experienced group will complete the Pilot Course with little focus. In addition, the ‘in training group’ is used to assessments and learning setups similar to those from the Pilot Course. However, due to small group sizes and the lack of significant differences, these results are not considered as relevant for this research.

Looking at profession; completion rates provide the most interesting insights. Figure 4.31 ‘Completion Rate by profession, not considering cohort groups. Excluding all participants with a CKQ score below 0% and professions groups containing less than six participants’ illustrates the highest completion rates appear under the group of participants currently working as BMET in a hospital. This group is familiar with existing issues and therefore sees the urge to develop a successful training and the urge to follow a BMET training with full focus.

Other possible characteristics or factors, personal or technical, influencing results showed no logical or significant correlation, as was shown in the previous chapter. Therefore these are no longer considered for this research.

## 5.2. Limitations and Improvements

When analysing results of a research, it is important to consider the limitations. In addition, before being able to give recommendations, possible improvements must be found. Whilst analysing this research, a few important limitations must be mentioned. First of all the group of participants; the group of people who participated was already motivated and aware of the present issues. Participation took six hours on average without any rewards or recognition, this requisites motivation. Therefore we can conclude no proper research could have been performed to investigate if intrinsic motivation could be stimulated, since we have to acknowledge that these participants were already intrinsically motivated.

The second limitation regarding the group of participants is the range of experiences among participants; the majority of the group was relatively high experienced. The final MOOC has a less experienced target audience. This must thus be considered when implementing recommendations originated from results. And obviously more participants from other regions, more women and a wider spread in age among the participants, would be given more valuable insights.

Another limitation from this research is the setup of the motivational incentives, especially the motivational video. The video was created and designed by and for participants from South-East Asia. The content was inspired by the South-East Asian culture. Therefore participants from other regions might not experience the same impact of the video, as they would have if the video would be adjusted to the relevant culture.

Apart from cultural limitations, the motivational incentives contained setup limitations and therefore leave room for improvement. In this research it was decided to limit the incentives to the two described incentives, which will only be shown at the beginning of the Pilot Course. Ideally a more repetitive and logical setup was implemented, where the job description and motivational incentive were elaborated on in great detail within a more logical module of the course. With regards to the final MOOC, the most logical placement would be in Module 1, where the role and responsibilities of a BMET are being explained. In addition, repetition ideally would be added to strengthen the effect. However, within the scope and capabilities of this research it was decided to limit the setup to only the above described incentives and setup. The reason was the possibility to create content; due to Covid-19 possibilities were limited, in addition our network was limited to the NSI, since cooperation from Africa did not manage to be launched within set timeframe and deadlines. Therefore it was decided to invest all resources on one motivational incentive, instead of multiple throughout the course.

Lastly, the main focus of this research was the creation of a Pilot Course to investigate the possibility to train BMETs via an online training. So all time and effort were devoted to that goal. In order to create an ideal setup for motivational incentives more extended research must be performed. Hereby techniques taught in persuasive technology classes, created by Stanford University, could be very useful. This methodology teaches how to coerce people into compulsively using technology and forms the basis for business models in Silicon Valley on psychological manipulation and addiction engineering for Social Media platforms. Implementing similar techniques could impact behaviour and influence the mindset of participants, which will be beneficial on the job as a BMET. It has been proven by multiple researches that people's behaviour and thus mindset can be changed or adjusted by Social Media [24][25]. Therefore it is assumed techniques can be imitated by other platforms reaching similar goals, that should be the aim within setting up the BMET MOOC.

The last limitation of this research is regarding the content. The content of the course was mainly created online, so based on existing material. A major improvement to the content and design of this course, would be to create all content from scratch. This enables a more consistent design and setup, in addition practical knowledge would be better explained when creating videos whilst working with the device. This limitation is partly caused by the current presence of Covid-19, making it complex to perform site visits at hospitals in LMIC. Equally, coming together as a team was limited due to Covid-19, forcing all meetings to be online. The course setup and design could be improved by creating all content with one consistent team. In that way participants are exposed to one professor only, each section is built up in similar manner and one device model is used as visual only. Thereby collaboration with a manufacturer, ensuring availability of adequate and workable information on how to repair and test equipment will significantly improve the quality and reliability of the content. Currently Original Equipment Manufacturers (OEMs) seem to limit access to this information or even block the information.

# 6

# Conclusions and Recommendations

This chapter will conclude this thesis by answering the research questions. In addition, this chapter will provide recommendations for both practice as well as further research.

## 6.1. Conclusions

Conclusions of this research are formed by answering the research question, which reads as follows: 'C*an the required level of knowledge and set of skills for Biomedical Equipment Technicians be achieved through a Massive Open Online Course?'.* Based on the results, it was found that Biomedical Equipment Technicians can indeed be trained and educated via an online training. Therefore the answer to the research question is yes; Biomedical Equipment Technicians can indeed be educated through a MOOC. However, considering the limitation of the scope of this research which is limited to the Pilot Course, further research should verify if the knowledge level and skill set acquired are indeed the required level to become a BMET. Assuming the set of skills and knowledge level would reach the required levels and so assuming the development of the MOOC would be the next step within this research, we will continue with the conclusion that a MOOC is the answer to the research question.

The MOOC must be setup with large variety in exercises and with exercise types applicable to practical knowledge. From this research we have learned participants prefer multiple choice, since the level of difficulty matches expectations and starting level of knowledge, multiple choice questions also help with possible language barriers. In addition participants prefer drag and drop exercises, which allow practical knowledge and capabilities to be tested. However, when drag and drop exercises are implemented, technical adjustments to the course material need to be done allowing participation from smartphones or tablets. It is recommended for the MOOC to require all participants to spend approximately four till six hours per week on the training. Lastly, the course must be setup in such manner that participants coming from different entry levels can efficiently and effectively participate. My proposal would be to have a ranking in the sections, so that participants with a higher entry level can start at a later point whilst all participants will have comparable exit levels.

Other conclusions are based on the sub research questions, researching the effect of motivational incentives and the impact segmented over participant characteristics. In conclusion we can say that the motivational incentives, in the forms currently used, had no significant influence on the grades received within the Pilot Course. The first explanation for this would be the setup of the motivational incentives; these require change and improvement. Limitations of the motivational incentives were both related to setup and content. The setup was driven by the limited recourses and knowledge on the topic, which is sub-optimal. Content should also be adjusted to match the different cultural backgrounds from participants and also by explaining consequences of being unsuccessful or failing.

The second explanation for the lack of significant influence of the motivational incentives as currently used, is the group of participants. The group of people participating in the Pilot Course was, due to background and prior knowledge, already aware of the existing issues of the large number of out of service medical and laboratory equipment and therefore difficult to motivate for the issue further. In addition, participation required time and effort of participants without any rewards, so it can be assumed it required motivation to complete the Pilot Course. Therefore motivational incentives had no significant results, the group was already motivated and could thus not be motivated more.

Additionally, it can be concluded that the motivational incentives had a negative result on completion rates. This could be subscribed to the incorrect content of the motivational incentives; the motivational video mainly. The video created an environment were doing your best, or only participating is enough. Instead a video should be created with a 'stick and carrot' approach so a less soft approach; less emphasizing the problem and more focus on content showing the consequences of failing.

Last of all, other characteristics; only two characteristics were found showing significant differences in results. The first conclusion is that participants from South-East Asia have a higher completion rate compared to participants from Africa, which is caused by the propensity to stick to discipline coherent to the Asian culture [23]. The second conclusion found, related to other characteristics of participants, is that BMETs currently working in a hospital have a higher completion rate. This group is familiar with existing issues and therefore sees the urge to develop a successful training and the urge to follow a BMET training with full focus. This provides the insight that a refresher course will attract a more motivated group of participants.

## 6.2. Recommendations

Based on the outcomes of this research recommendations are given. This section will elaborate on recommendations stemming from this project, divided into recommendations for further research and recommendations for practice.

### 6.2.A Recommendations for further Research

Recommendations for further research are twofold; recommendations related to the final MOOC and recommendations related to stimulating intrinsic motivation among participants. First of all, more research should be done on the possibilities and the viability to influence behaviour in an online platform, so the possibility to stimulate intrinsic motivation during training to perform better on the job as BMET. Inspiration for possibilities to stimulate motivation should come from social media and techniques taught in persuasive technology classes, created by Stanford University. Based on the theory behind those techniques, the setup for motivational incentives should be adjusted.

In addition, the existing environment in which current BMETs in LMIC are working must be carefully mapped. The assumption is that the working environment offered, attracts people who tend to follow, do not take initiative on their own and that they tend to avoid failure. These could be elements from collective cultures like we find in Nepal and Kenya [22]. Thereby it must be noted that the current existing environment, lends itself perfectly for not performing since no consequences exist for being unsuccessful or failing in your job. Therefore, research must be performed in how to change the mindset of people working in such environments; change the mindset towards being active, taking ownership, taking initiatives and taking risks. In this research different cultures and backgrounds must be taken into consideration. Current systems are often based on Western techniques and cultural characteristics, the research that is being advocated should be applicable towards a system applied to the actual cultures, where the program will be running. The findings from this work should be combined with the most efficient methods to implement motivational incentives in an online training. Subsequently, research should show the impact of the adjusted incentives on the performance on the job. So the proposal would be to run a research project with a scope not limited to the training, but capable of measuring effectiveness after the training has completed.

Secondly, a test version of the final MOOC should be created in edX, to be able to verify the setup and possible technical issues or limitations from this approach. As we would be using the complete version of the MOOC in such a test, this will verify the setup and structure of the different modules and sections. An ideal placement for motivational incentives can simultaneously be identified. The recommendation would be not to limit the scope of this trial to the MOOC only, but to use an approach that would be able to review and analyse results from the MOOC in practice. This should confirm the conclusion found in this research that BMETs can be educated to the required set of skills and knowledge level through a MOOC. The work done so far could only show that participants are educated with knowledge and skills they were exposed to, but the scope of this research did not allow testing and verification if those skills and knowledge are indeed the required level. Further research must thus verify this.

When setting up all the above recommended research steps, the group of participants must be configured in a more effective way. Participants from this research are already working as BMET or following training, whilst the MOOC will mainly be developed for people not having access to training and people who are not active as BMET. In addition, participants from this Pilot Course were already motivated; participation without any rewards or recognition took time and effort and therefore required motivation. That created a bias in this research, so would ideally be prevented in future research. Furthermore, more participants from other regions, more women and a wider spread in age among the participants, would be given more valuable and reliable insight in the total matter.

Lastly, when designing the final MOOC my recommendation is to create all content from scratch which enables a more consistent design and setup. Additionally, practical knowledge would be better explained when creating videos whilst working with the device.

In addition, I recommend collaborating with an Original Equipment Manufacturer (OEM), ensuring availability of adequate and workable information on how to repair and test equipment and even get their feedback and input to our deliverables. This will significantly improve the quality and reliability of the content. Currently OEMs seem to limit access to this information or even block the information. Starting a collaboration might show a way around this issue or at least make it better understood. Further recommendations with regards to the setup of a MOOC are given in Appendix C.

### 6.2.B Recommendations for Practice

Most importantly my recommendation for practice is to continue the development of a MOOC to train Biomedical Equipment Technicians in LMIC. From this research it became clear the development of a MOOC is a very effective step in solving the presented issue. It has not been proven that the acquired knowledge level and set of skills is at the required level, however it is proven that the exposed material is mastered by the participants. In addition this research revealed the large demand for a remote course accessible to all and free of charge to train and educate Biomedical Equipment Technicians.

When setting up the MOOC my recommendation is to follow the findings and recommendations from this research and to consider local contexts and cultures. A MOOC setup accordingly will decrease the number of out of service medical and laboratory equipment in LMIC, increase education in LMIC and thereby increase health care and standards of living in LMIC.

In addition, when analysing possible solutions to the identified issue of the large number of out of service medical and laboratory equipment, and then specifically looking at the knowledge gap of how to use, maintain and repair medical and laboratory equipment and the missing motivation of BMETs in LMIC, one must consider options that would go a lot further than just setting up an online training. The knowledge gap should be solvable, or at least be improved when setting up and implementing a MOOC to effectively train BMETs. However, the failing- or missing motivation among BMETs in LMIC is a big contributor to the issue and must therefore be addressed as well. It seems best to seek improvement by approaching the problem bottom up. So by adjusting hierarchy, status quo and the working environment in local hospitals by collaborating with health organisations present locally. This is already done in Nepal for example, BMETs working in private hospitals led by health organisations are many times more effective compared to BMETs working in public hospitals led by the government [8]. However, that is a local solution to the existing problem. Global or at least less-local solutions, apart from the one suggested in this research, would be to collaborate with governments. Governments could set up similar control and management mechanisms as health organisations present within hospitals, especially when being helped by a leading university and with the availability of a MOOC to train BMETs. From the other perspective this collaboration could also benefit the setup of the MOOC, since governments could provide useful insights; concerning local context, existing issues and in creating a better understanding of the culture.

So in summary my recommendation for practice is to create and implement a MOOC to train BMETs in LMIC, considering local contexts and cultures and expanding the MOOC with a system tackling the issue of missing motivation among BMETs. By doing so, the knowledge gap will be closed and a first step towards improving the issue of missing motivation is made. This will decrease the number of out of service medical and laboratory equipment and thus improve the overall health care system in LMIC.

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# Appendix A

## Literature Study

This appendix gives a more complete literature study, aiming to provide the theoretical background of the study. It is based on the literature review: 'Motivation for Biomedical Equipment Technician Training in Low-/ Middle- Income Countries'[11] [11]. The summary found in this report is based on the more extended summary of the full literature report, given below. First of all, this appendix elaborates on motivation; definitions from literature, different types and phases of motivation and cultural differences. Secondly, three learning models applicable to this application will be summarized and methods of learning among various cultures elaborated on. Lastly, the current situation of BMETs and health care in LMIC is clarified.

### A.1. Motivation

Motivation is defined as 'the will to do something' [26]. Motivation is a very important factor in training. First of all, motivation is required to start a course or training, second of all motivation is key in finalizing a training or course successfully. When referring to motivation of a potential BMET in an online training, the motivation during and prior to training is meant, but more importantly the motivation after completion of the training while working as BMET is meant. Many medical and laboratory equipment reported as out of service could easily be repaired by the currently active BMETs in LMIC, however due to lack of motivation and due to frustration, this is not being done [4]. The training must be designed such that BMETs will be inspired and motivated to be a BMET and thus to do their job and tasks. In summary the scope is limited to the training itself, but results must lead to success after completion of the training, whilst being active as BMET in LMIC.

#### A.1.A. Types of Motivation

Motivation within literature is defined and used in many different manners. The overall meaning is equal, however, the context and detailed description differs throughout literature. P. K. Murphy and P. A. Alexander created an overview of all terms and definitions used to explain motivation, in their article; "A Motivated Exploration of Motivation Terminology". The overview can be found below in Figure 2.1.

[11] This report has already been graded and ECTs have already been assigned. The review was initially written to fulfil my Literature Study, a compulsory element of the complete graduation. A summary of the study has been given here to provide a complete research, including the literature study performed prior to this thesis project.

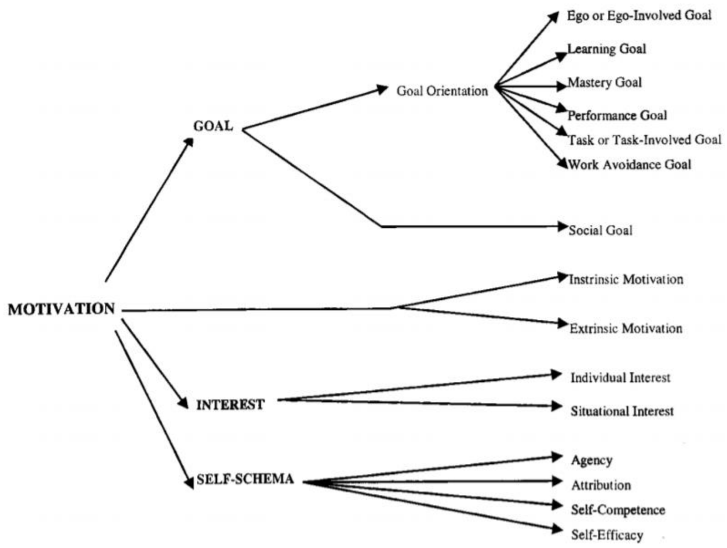



FIG. A.1 The resulting corpus of 20 motivational terms relevant to academic achievement and motivation [12].

From this figure, we will look at all overall forms; (1) Goal, (2) Intrinsic versus Extrinsic Motivation, (3) Interest and (4) Self-Schema. The detailed descriptions of these terms will not be elaborated further, but only used to explain and expand on the set terms. The terms within the figure where defined based on literature studies focused on the construct of academic achievement or academic development. The aim of P. K. Murphy and P. A. Alexander was to create a theoretical overview, purely based on literature and proven theory [12].

#### A.1.A.1. Goal Driven Motivation

A goal is defined by Wentzel as: 'What students generally want to achieve in their classes be it academic or social' [13]. This can drive motivation, goal orientated motivation is thus defined as 'a set of behavioural intentions that determine how students approach and engage in learning activities' [27]. Within this definition, differentiations are made, which can be split up into three incentives; (1) the motivation to actually gather the knowledge and competence, (2) the motivation for performance and to influence judgement and last (3) the motivation originated from the desire to limit the amount of effort needed [12]. Different authors and reviews refer to different definitions, depending on the set context of the research. In the contrary of goal orientated motivation, social goals also give incentives for motivation. Social goals are originated from the social aspects and consequences of performing certain tasks, so they are performed to please others or driven by social responsibility [13][28]. Looking at these definitions, it can be concluded that goal driven motivation can come from within, but can also be driven by external factors. With regards to external factors, the context and personal situation matters.

#### A.1.A.2. Intrinsic versus Extrinsic Motivation

The most common distinction within motivation is made between extrinsic and intrinsic motivation. Intrinsic motivation is defined as 'the internal drive to engage or perform' [12][14]. In other words, intrinsic motivation is a drive from within, not caused by external factors. In contrary, extrinsic motivation is defined as 'motivation from rewards given for appropriate behaviour' [14]. So extrinsic motivation is caused by external factors, often encouraged by financial rewards. However, those definitions are used differently and are widely interpreted. In 2000, Noels et al. changed the generic labels of extrinsic and intrinsic motivation to external regulation and integrated regulation. With external regulation, he meant external factors influencing motivation, which can be regulated and thus influenced. The exact opposite, internal regulation, is the factor of motivation influenced by internal factors, also regulatable. This converted the terms into a scale, showing external influences can be internalized and the other way around [29]. Leading to the conclusion that both terms are not as black and white as often stated.

#### A.1.A.3. Motivation driven by Interest

Motivation driven by interest, where interest is defined as the underlying needs and desires by which the process of learning is energized [15]. Within motivation driven by interest, a distinction can be made between individual and situational interest. Both forms are motivation driven by an individual's interest for a certain subject or matter. However individual interest is driven by a personal history, one's character and by desires which is long-term and not temporary. Where situational interest is driven by short-term events, objects, contexts or characteristics and thus temporary [12]. In the review of John Marshall Reeve, it is stated that interest contributes to intrinsic motivation by initiating and directing attention of the subject to a certain matter. He also states there is an important difference with regards to motivation between interest and enjoyment. Enjoyment also contributes to intrinsic motivation, but by sustaining the willingness to continue [30]. So in summary interest is needed to start a certain task or activity, where enjoyment is required to continue [30].

#### A.1.A.4. Motivation through Self-Schema

Self-Schema is defined as self-knowledge, mainly referring to individual differences in perceiving and responding to events. Within Self-Schema different more specific definitions can be found, but in general Self-Schema motivation refers to a self-chosen manner to learn and develop, based on proper self-knowledge. This can be based on known learning capabilities, on assumed judgements or on known abilities. It can be compared to self-concepts, which is a collection of assumptions, views and beliefs about oneself, answering the question who you are. However, Self-Schema is more dynamic and more situational and thus less permanent [12].

### A.1.B. The different Phases within Motivation

A research by Chen, Warden and Chang, investigated motivation in language learning. In their research they defined three phases of motivation, with different incentives per phase. The overview is visible in Figure 2.2 below.

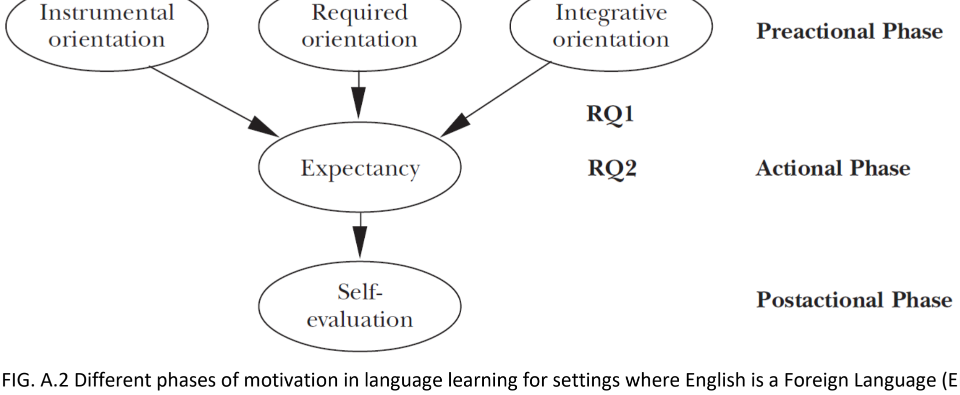



FIG. A.2 Different phases of motivation in language learning for settings where English is a Foreign Language (EFL) [16].

The first phase is the Preactional Phase; the phase prior to action, in which motivation must be initiated. Motivation can be driven by three different incentives. The first incentive is Instrumental Orientation, this is a form of extrinsic motivation in which the incentive is driven by the benefits of learning. Benefits mostly range between money, job prospective or similar motivators. The incentive is based on the principle 'return on investment'. The second incentive, Required Orientation, can be seen as 'forced motivation'. The incentive is not true interest but requirement from environmental settings. The last incentive, referred to as Integrative Orientation, is driven by the desire to belong and fit in. While referring to learning a language, it is motivation to learn the language the environment is using [16].

The second stage is the Actional Phase; in which motivation must lead to action. Motivation must guarantee the participant continues participating and finalizes the course, also motivation must increase results. Motivation in this phase is led by expectancy, meaning the participant will remain motivated when expectations are met.

The last phase is the Postactional Phase; this is the critical retrospective phase after the action has completed [16]. The training has officially finished when this phase is reached, however learning and remaining knowledge has not finished. In order to maintain the acquired knowledge, motivation within this phase is crucial. The participant must constantly continue practicing and test his or her own knowledge. When motivation in this phase is high, the participant might even continue learning. The learning process within this phase is the responsibility of the participant and will be led by his or her retrospective judgement [16].

### A.1.C. The Effect of Culture and Cultural Differences on Motivation

When understanding motives of individuals, it is important to acknowledge and understand one's norms and values and thus his or her culture. Culture is hard to define, however with regards to motivation a researcher called Hofstede came up with a very useful dimensional definition. In his theory he separated culture in five dimensions, leading to variating cultural values; (1) hierarchy, (2) identity, (3) gender, (4) uncertainty and (5) orientation. The first dimension, hierarchy, describes the extent to which less powerful groups accept an uneven distribution of power. His research states 'coercive and referent power' is conventional for high societal communities, whereas rewarding and legitimate power is more usual to low societal communities. Looking at the second dimension, identity, explains the extent to which individuals are part of a group or society or more self-centred. The research found individualistic cultures expect people to take care of themselves, where collectivist cultures exist of groups in which people are integrated with strong bands and dependency. Thirdly, gender, describes the distribution of roles between man and women in society. This distribution is more evenly divided in feminine cultures. Fourth, uncertainty describes the acceptance for uncertainty among a society. The dimension indicates whether people from a certain culture are comfortable or uncomfortable with uncertain and unknown situations. Cultures not tolerant for unclarities or uncertainties implement rules and regulations, to avoid these uncertainties. Where uncertainty tolerant cultures allow more freedom and opinion differentiations and limit the number of rules. The last dimension, orientations, distinguishes long term cultures from short term cultures. Long term cultures have perseverance and thrift values, focussing on long term consequences and goals. Short term cultures are led by values respecting tradition, measuring up to social expectations and saving one's face [31].

In addition to the five-dimensional definition, Hofstede states culture effects nonverbal behaviour as well. Part of the identity dimension for example, is the expression of emotion and whether this is acceptable among a culture or not. In the United States it is acceptable to express negative emotions like fear, anger or grief, whereas in a collectivistic culture like Japan this is not accepted.

## A.2. Learning Models

In literature, several different learning models can be identified. A selection of those models found in literature and judged on most relevant for this application are summarized below. The selection is based on the context of LMIC, the final appliance of this research, the importance and relevance of motivation within the model and the possibility to apply suggested methods.

The models selected are based on the following theories;

1. Learning strategy based on motivation
2. Learning strategy and motivation based on expectancy
3. The critical role of retrieval practice in long-term retention

### A.2.A. Model 1

The first learning model or learning structure is based on the link between motives for learning and learning strategies. Multiple studies have been performed, investigating the different learning strategies, different motives for learning and possible links between them. Reflecting the model in literature, two different strategies have been identified; deep-level and superficial-level processing, also referred to as meaningful and rote learning [32]. Based on this broad finding, a combination of research institutes has tried to create a link between motives and strategies.

The model created, in which strategies are chosen based on the underlying motives for studying, was based on three types of motivation; instrumental, intrinsic and achieving. These motives where aimed to be linked to three different learning strategies; utilising, internalising and achieving. This elaborated theory originally came from Biggs. He defines his theory and thus the links between motives and strategies as follows; The first link is based on instrumental motivation, meaning the motivation to study is based on the desire for, among others, a salary increase, promotion or to undertake further study. So based on extrinsic, instrumental rewards when successful in studying or the tasks performing. The strategy linked to this motive, utilising, is in general mainly focussed on avoidance of failure. More specifically this means limiting effort, superficial fact learning, based on passing tests and exams rather than deeply understanding the matter [17].

The second link, where intrinsic motivation is leading, is formed from the desire within to develop abilities and special interests. The student is motivated to work out his or her life goals and philosophy. The strategy chosen, when driven by intrinsic motivation, is to deeply dive into the matter, to perform extended reading and to completely understand the subject, independent and most certainly not limited to set requirements for tasks or tests. The subject is made personally meaningful to the student by studying according to this strategy. This strategy is therefore referred to as internalising [17].

The last link is the link between motivation driven by achievement, coupled to the strategy referred to as achieving as well. An achieving motive is recognized by the urge to win and excel, so to fulfil a competitive approach to life and to excel in what you do. In more detail and applied to studying, one will study with the aim of maximizing results and thereby achieving a high status. The achieving strategy linked to this motive is a diligent attitude, a structured working schedule and a hard working mindset [17].

Multiple studies have proven that students with a specific motivation choose a congruent learning strategy [32], as stated here. However, research has not identified the influence of culture for this model, it could be this theory and thus this model is country bounded [17]. Another downside from this model, is that the motive for studying is hard to influence or change, therefore steering towards a specific learning strategy or outcome is complex.

### A.2.B. Model 2

As mentioned before; learning progress is strongly dependent on the expectancy of the student. The second learning model is based on this knowledge and a review of Janet Metcalfe and Nate Kornell. The model referring to is the 'Region of Proximal Learning model'. The model is based on the theory that learning is led by expectation and self-efficacy. When starting, the student will eliminate all known items or subjects. Subsequently the student will prioritise the unknown items based on assumed level of difficulty, where one will study the remaining subjects in rang order, from assumed easy to difficult. Whilst studying, the student must decide when to quit an item and continue to the next item or continue with further studying, this is done based on the self-judgement of progress. So, according to the model, the student will continue as long as he or she is perceiving himself to be learning. The student will stop and continue to the next item when learning is no longer paying off and progress has stopped [18].

### A.2.C. Model 3

A study by Henry L. Roediger III and Andrew C. Butler showed the importance of practice and developed a learning model in which practice is implemented and fulfils an important role.

It has been assumed, that learning only occurs during studying. Testing and practicing were assumed to purely function as assessment for the learned material. However, according to Roediger and Butler, practice has a positive impact on long term retention and functions as a very powerful mnemonic enhancer [19]. Mnemonic enhancers have positive impact on long term retention, so enable the student to memorize the studied material instead of only reproducing when tested shortly after studying. Due to practice the student will thus gain a superior long-term retention concerning the practiced material, where studying an equivalent amount of time will enable a more short-term knowledge retention. A second benefit according to their research is that practice provides flexibility in retrieval of information and thus enables the student to use gained knowledge in different settings and contexts as well. The mnemonic enhancers help to produce more than only a simple response, it helps in understanding the underlying theory and thus to translate the knowledge to different contexts [19].

Studies have stated retrievals are only effective when performed errorless or at least with limited errors, however other studies showed the first retrieval should have a delay, to higher the level of difficulty. When a delay is short, the retrieval of information is assumed too easy and thus produces little to no mnemonic and long-term retention benefits [33]. So when retrieval is relatively easy, for example due to very short intervals, even a high number of retrievals have little effect. However, under better circumstances, when retrieval is experienced more complex, even one test can have significant effect on retention [34]. Ideal is repeated retrieval under the right circumstances, to maximize later retention [35]. When looking at circumstances, three possible interval schedules have been examined; (1) expanding interval, so increasing time between practice retrievals, (2) equal-interval, so remaining time between retrievals equal and (3) massed schedule of practice, where all practice runs where massed into a short period of time right after studying. Research concluded both expanding interval and equal-interval have higher retention compared to massed schedule of practice, even though the massed-schedule was performed almost errorless. Which confirms the conclusion stated earlier; repeated retrieval of information directly after study produces little retention [36]. the retrieval must be under certain circumstances so that it is not perceived relatively easy. The difference between equal-interval compared to increased interval, is that the first test for equal-interval requires more effort, since the delay is often larger. The increased effort should lead to improved long-term retention. However, the benefits of multiple retrievals of information decrease, since the amount of effort needed decreases, especially compared to increased interval. As concluded earlier both models are suitable, as long as wide spacing between retrieval attempts is maintained, even if some errors are made [19].

### A.2.D. Methods of Learning among Different Cultures

When educating people to become a BMET via an online platform, it is crucial to educate them to solution-oriented thinking. Since a BMET must diagnose and repair medical equipment, different types of equipment and different problems causing the defect will become their responsibility. In order to do so, the training must take the participants along towards solution-oriented thinking, starting from their current learning style.

According to research by Kolb, learning involves all human activities: (1) feeling, (2) reflecting, (3) thinking and (4) doing. Individuals will develop a personal preference for one of those activities and will develop capability of learning using that activity. When referring to a learning style, one of those preferences or activities is meant. In according to this differentiation, he developed a model explaining different learning styles. Within his model, a person is required to be capable of working will all four key learning abilities. In the model he has defined the four key learning abilities as follows: (1) concrete experience (CE), (2) abstract conceptualization (AC), (3) reflective observation (RO) and (4) active experimentation (AE). The first learning ability, CE, is focussed on being involved in experiences and practice. The accent on CE is on using feeling, therefore people preferring CE ability value social contact, relations and cooperate well on an open-minded approach. In contrast to CE is AC, the second ability, a mainly rational ability. AC is focussed on and specialised in applying logic, thinking, analysing and working with models before implementing. Therefore people with AC as preference are good at manipulating, quantitively analysis and systematic plans. Thirdly, RO abilities focus on reflective understanding, so finding out why and how things happen. Qualities of RO preferred people are perspective thinking and imagining meanings of situations and thoughts. Lastly, AE abilities, are the opposite of RO abilities. The focus of AE abilities is on trial and error, practical applications and a pragmatic approach. People working according to AE abilities dare to take actions and risks, desire responsibilities and get things done [57]. The model described here, is visualised in Figure 2.3 below.

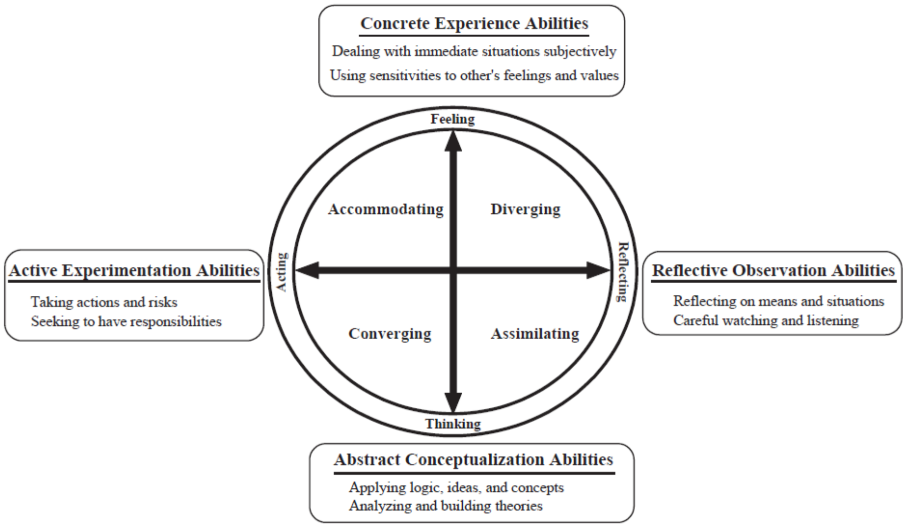



FIG. A.3 Learning styles and learning abilities (Kolb) [37].

Different learning styles according to Kolb are defined, however the question remains how this relates to culture differences. Research by Hall in 1976 made a cultural classification, where a differentiation was made between high-context and low-context cultures. The differentiation is based on the importance to individuals of contexts applied to communication. Where people belonging to high-context cultures determine the meaning of certain messages dependant on non-verbal behaviour, external physical environments and surrounding situations. Research found that high-context cultures are led by CE abilities where low-context cultures learn through AC abilities. The second cultural classification differentiates shame versus guilt cultures. 'The emotion shame is a reaction to criticism of audience' [57]. Shame cultures are filled with environments for good behaviour and surrounded by external sanctions. In order to evoke the emotion of shame as a physiological reaction, one must dispose of the CE ability. On the other hand; guilt cultures are more rational. The culture develops inner standards of behaviour formed by individual's self instead of external standards formed by the opinion or standards of audience. The capability for developing these self-created inner standards requires RO abilities. Another cultural classification is uncertainty avoidance. The research states uncertainty avoiding cultures to learn through RO ability. In contrary, cultures not or limited avoiding uncertainties tend to learn through AE abilities. People preferring AE abilities have developed a learning style consisting of action and risk taking and practical application. In contrary, people from an uncertainty avoiding culture feel uncomfortable with unexpected and unstructured circumstances. They prefer rules, regulations and structure and thus not risk and action taking. They also prefer model creation instead of practical application. The fourth cultural classification is applied to organizations within or belonging to those cultures; M-type versus O-type organizations. M-type organizations provide clear job descriptions, in which tasks and responsibilities are clear and defined using verbal expressions. People working for those organizations and thus belonging to that culture are required to develop analytical cognition, which forms the basis for AC abilities. In contrary, O-type organizations lack clear job descriptions and boundaries. However, employees are aware of their responsibilities and tasks based on experiences and informal alternative face-to-face channels. O-type orientated people are people- instead of task- orientated, which correlates to CE abilities where interpersonal contact and social issues are relevant. The next classification divides interdependent-self cultures from independent-self cultures. Interdependent-self cultures tend to learn through both CE and RO abilities, whereas independent-self cultures learn through AC and AE abilities. Interdependent-self led cultures can be compared to collectivism whereas cultures corresponding to independent-self led people is analogous to individualism. Western Europe and American cultures are mostly independent self-led. Examples of interdepend-self cultures are Asian, African, Latin American, and many southern European cultures. The last distinction made is between field-dependant and field-independent cultures. Field-dependent cultures have a less autonomous functioning compared to field-independent cultures. The less autonomous functioning enables the possession of social orientation and emotional openness in communication. Comparing these characteristics to Kolbs model shows field-orientated cultures possess CE abilities, which are characterised by being fully open to new experiences and connecting to the outer world, so led by social relationships. Field-independent societies on the other hand have autonomous functioning and prefer abstract activities and have impersonal orientation. These cultures relate to AC abilities, since people preferring the AC ability rely on abstract concepts and logical and analytical cognition. In contrary to field-dependent people, field-independent people are more task-orientated [57]. The correlations are summarised in Figure 2.4 below.

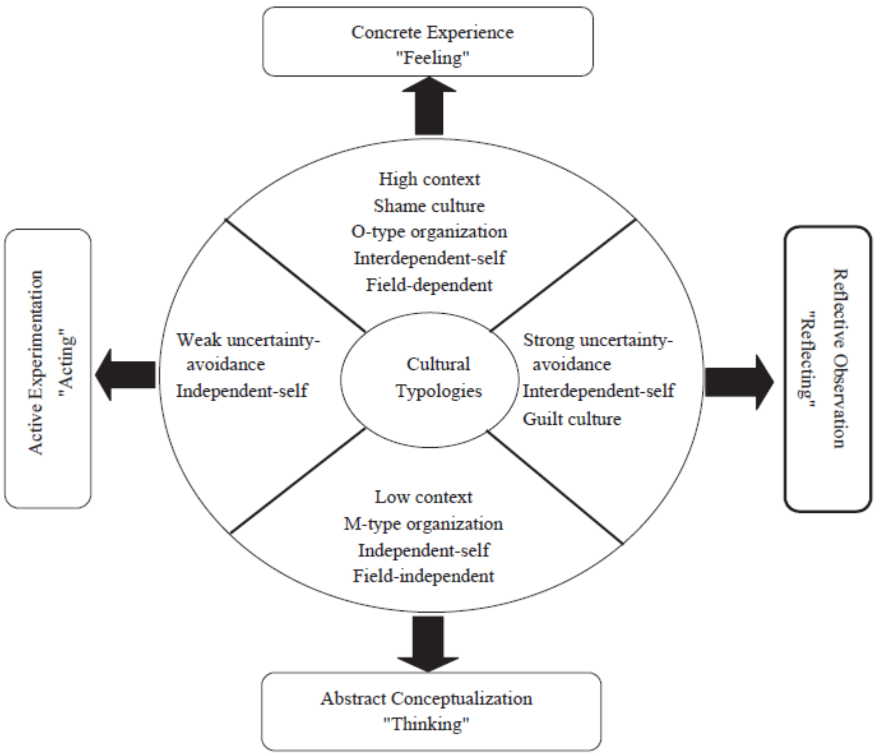



FIG. A.4 Correlations between cultural classifications and learning abilities [37].

## A.3. Current Situation

In the current state of affairs, it is clear we are getting things wrong. Equipment is not being used, due to malfunctioning of the equipment or broken parts. However, the equipment is very much needed. Local populations have already done many attempts in order to improve the current situation in differentiating manners an forms [20]. Some have been beneficial and effective, however there are still many improvements required. Returning to the conclusion stated in the introduction; the hierarchy and communications towards and around BMETs existing in LMIC does not give them incentives to be successful. The current existing lack of incentives is partly due to the implemented Western and Euro-American way of communicating and rewarding within hospitals and towards

BMETs. In order to give BMETs in LMIC incentives to be successful one must identify and recognize their cultures and drivers towards success. Looking at Nepal for example, core drivers for motivation are recognition by senior members of communities and societies and preventing loss of face [33]. Practicalities in order to live out these drivers have been discussed in previous chapters, but the important point here is that motivation is the key word and in order to effectively stimulate people one must understand, respect and apply their values, not ours. Implementing a mechanism in which their success is recognised, responsibility morally increased and failure connected to social consequences, will have serious impact on motivation in collectivistic cultures and thus success rate [33]. In addition, a training must be developed accessible to all; so free of charge and remotely accessible; a Massive Open Online Course (MOOC). Ideally a training is developed combining both improvements required; educating potential BMETs with the required knowledge set, whilst stimulating motivation to perform.

### A.3.A. Current knowledge and capability of BMETs in LMIC

According to literature, BMETs in LMIC have several limitations, both internal and external. First of all many BMETs have high school as highest level of education, where the quality of the high school is unknown. So knowledge and experience are very limited. One of the consequences is that many BMETs do not speak English or only limited. Many courses or forums available require you to speak or at least understand English. Also many equipment manuals, if available, are in English and the manufacturer can only be consulted in English. Many BMETs operating do not have access to a computer or to internet. Therefore it is important to design a training which is also applicable from a mobile phone and where content can be downloaded. However, no access to internet gives a major limitation to an online training. Operating BMETs within hospitals report having very limited access to tools, most only have access to regular screw drivers, but no advanced tools whatsoever. Lastly, many BMETs are frustrated, first of all by the limited working environment as described here. Second of all by the status quo and hierarchy within hospitals; BMETs are not fully trusted or not trusted at all. This leads to frustration, demotivation and thus a non-operating BMETs or a BMET not aware of issues and broken machines, since the other staff will not involve and inform them [38].

In addition to lack of knowledge, a problem often existing in LMIC with regards to BMETs is related to region. Take Nepal as example, the Nick Simons Institute, NSI, offers a training for high school educated potential BMETs of one and a half year, however over half of the graduated BMETs remain working in the Kathmandu region [21]. Resulting in a shortage of educated technicians in rural Nepal. 40% Of the graduated BMETs who did go to the mountains for work, where recruited by private hospitals, leaving governmental hospitals with a shortage [21]. Similar situations and differentiations between rural and metropolitan regions occur in other LMIC.

Last of all, when designing an online training for BMETs in LMIC, one must decide or deviate in starting level of the participants. Some of the potential participants have no experience and not followed any training or course so far, others might have followed training before but require additional lessons and skills. So when designing a training, the target audience must be clear, in which a decision can be made between two possible target audiences and thus type of training; (1) novice training and (2) refresher/ continuous training. Novice training is meant for people without any experience or previous training. Refresher/ continuous training is meant for BMETs who have followed training before and either need refreshment of learned knowledge and skills or require additional education since skills and knowledge sets were not included in the followed training, or at least not sufficiently or correct. Ideally the training would be accessible for all, where a clear deviation of starting point is made. When such a construction is set up, one must consider a mechanism guaranteeing participants all having the same level when starting not at the beginning of the training. This could be done by an admission test or by obliging a very short pre course to fresh up all previous learned knowledge.

### A.3.B. Required Knowledge of BMETs in LMIC

A research by Robert Malkin and Allison Keane investigated what skills and how many skills, are required to master as a BMET in resource-poor settings. Their research pointed out only six domains of knowledge are required. When mastering these six domains, 99% of all repairs commonly occurring in these settings, can be accomplished. The domains are as follows, with percentage for repairs possible to accomplish when mastering the knowledge in brackets; (1) electrical (18%), (2) mechanical (18%), (3) power supply (14%), (4) plumbing (19%), (5) motors (5%) and (6) installation or user training (25%). Underneath these domains, certain skills are coupled. In order to determine to what extend a domain is needed to be mastered, each domain is divided into units, except installation or user training. Units are divided such that skills and concepts related to diagnose and resolve a problem are coupled. Assumed these repairs can be resolved with locally available equipment and materials. Afterwards the units where labelled according to complexity; either basic or advanced. Basic as label was given to skills requiring only locally available material and equipment and requiring skills capable to learn within one to two hours by a qualified person. A person is qualified when capable of reading, writing and doing math through fractions, no further prior knowledge is required. Based on these categorisations their research states only 107 skills are necessary to repair 65% of all out of service medical and laboratory equipment. These skills cover basic knowledge of the mentioned domains and can be easily picked up with little background knowledge or experience [2].

## A.4. Conclusions Literature Report

Based on literature, two important improvements must be implemented; a training free of charge, accessible to everybody but designed considering contexts of LMIC must be developed to increase the number of sufficiently trained BMETs, also in rural developing areas. In addition, motivation among active BMETs must be increased, which must be done by recognising local cultures and values. If these two improvements could be implemented as one in a MOOC, the problem of large numbers reported out of service medical and laboratory equipment can be decreased at global scale. Since also local hospitals in rural areas will be capable of appointing a trained BMET and active BMETs will be more likely to perform as desired.

# Appendix B

## Final MOOC

This appendix will elaborate in more detail on the content and setup of the final MOOC to train Biomedical Equipment Technicians. As explained before, the content and setup are not final, but have formed the basis in the development of the Pilot Course for this research. Below, an overview is given of what the content of the MOOC will be, split up into courses and modules, based on a document developed by the design team from Delft University of Technology [39]:

Course 1 - Basics of Biomedical Equipment Maintenance for BMETs

- Module 1: Health Technology Management
    - Understand the role of Health Technology Management practices and equipment life cycles, in low resource settings
    - Understand the role and importance of preventive maintenance and repair of medical equipment in low resource settings
    - Understand the importance of standardization of equipment
    - Understand the importance of good, accurate inventory management
- Module 2: Preventive Maintenance of Medical Equipment in Low Resource Settings
    - Risk assessment; coupling maintenance to patient safety risk
    - Setting up preventive maintenance programs, procedures, and schedules based on risk assessment
    - Resources needed for preventive maintenance
- Module 3: General Working Principles of Medical Equipment in Relation to Human Physiology
    - Diagnostic equipment, e.g.: pulse oximeters, patient monitors, etc.
    - Therapeutic equipment, e.g.: life support equipment, surgical equipment, etc.
    - Analytical equipment, e.g.: laboratory equipment, etc.
    - Miscellaneous equipment and processes, e.g.: sterilization equipment, medical waste management
- Module 4: Supporting Topics
    - Clinical user instruction/training
    - Patient safety and hygiene
    - Technical specifications
    - Inputting in procurement process
    - Regulations for medical devices
    - Learn how to use Google, Google Translate and YouTube to get access to user manuals/maintenance and repair guidelines
    - Available information on medical devices from WHO

After completion of Course 1, learners will be able to (1) understand the working principles of common medical equipment, (2) manage health technology within the hospital, (3) give input on the hospitals procurement process and (4) use online recourses to find relevant information on medical devices.

Course 2 - Maintenance and Repair of Biomedical Equipment

- Module 1: General Engineering Skills and Good Practices
    - Electronic circuits and drawings
    - Electronic equipment (basic principles of biomedical electronics)
    - Engineering mathematics
    - Data communication
    - Electronic controllers
    - Logic circuits
    - Measuring instruments
    - Using the inventory and keeping records
    - Basic general principles and good practices of maintenance, e.g.: safety testing, calibration, inspection, recording work, verifying settings with users after maintenance.
- Module 2: Maintenance/Diagnosis/Repair of Diagnostic Medical Equipment (e.g. pulse oximeters, patient monitors) in Low Resource Settings (for each core equipment)
    - Equipment X
        - Preventive maintenance
        - Troubleshooting/Diagnosis
        - Repairing
        - Testing
- Module 3: Maintenance/Diagnosis/Repair of Therapeutic Medical Equipment (e.g.: life support equipment, surgical equipment, electrosurgical equipment, etc) in Low Resource Settings (for each core equipment)
    - Equipment X
        - Preventive maintenance
        - Troubleshooting/Diagnosis
        - Repairing
        - Testing
- Module 4: Maintenance/Diagnosis/Repair of Analytical Medical Equipment (e.g.: laboratory equipment, etc) in Low Resource Settings (for each core equipment)
    - Equipment X
        - Preventive maintenance
        - Troubleshooting/Diagnosis
        - Repairing
        - Testing
- Module 5: Corrective Maintenance/Diagnosis/Repair of Miscellaneous Equipment (e.g.: sterilization equipment, medical waste management) in Low Resource Settings (for each core equipment)
    - Equipment X
        - Preventive maintenance
        - Troubleshooting/Diagnosis
        - Repairing
        - Testing
- Module 6: Supporting Topics (copy/duplicate from Course 1)
    - Clinical user instruction/training
    - Patient safety and hygiene

  - Technical specifications
  - Inputting in procurement process
  - Regulations for medical devices
  - Learn how to use Google, Google Translate and YouTube to get access to user manuals/maintenance and repair guidelines
  - Available information on medical devices from WHO

After completion of Course 2, learners will be able to diagnose and repair common problems of medical equipment within the hospital.

*Optional*: Course 3 – Train the trainers of BMETs.

- Covering topics of Course 1 and 2 in more detail, expecting knowledge of Course 1 and 2 already mastered

This will be a follow up course, which is aimed for after successful introduction of Course 1 and 2. After completion of Course 3, learners will be able to train new potential BMETs in the understanding of common medical equipment.

# Appendix C

## Storyboard and Blueprint

This appendix will elaborate on the storyboard and blueprint created before the Pilot Course was developed. Both functioned as basis for the setup and design of the Pilot Course. This appendix will illustrate both, as setup when designing the Pilot Course, and will recommend how to adjust both based on results from this research and findings whilst designing the Pilot Course in edX Edge.

### C.1. Storyboard Pilot Course

When creating the storyboard, a set template was used and filled in. This template and its setup are given below. As visible, a colour scheme is used to illustrate the focus of a certain topic or assignment. It is stated that a course is most effective when a variation of all types, and thus colours, of learning methods is used. So when designing the storyboard, it was aimed to use as much different colours and thus techniques as possible. The design of the Pilot Course was created in collaboration with the complete team responsible for the creation of the MOOC. However, it was mainly created by Daniel Garcia de las Heras and me for this research. My focus was on Section 0: 'introduction to the Pilot Course', Section 3: 'Preventive Maintenance', Section 4: 'Troubleshooting, Repair & Testing' and Section 6: 'End of Pilot Course'. Section 5 was created in collaboration, focusing on different subparts belonging to the before allocated sections, and the other sections were focused on by Daniel Garcia de las Heras. Therefore, this appendix will elaborate on sections 0, 3, 4, and 6 and parts of Section 5.

Colour Legend: Assimilative | Experiential | Finding & Handling Information | Communication | Productive | Adaptive | Assessment

| Section | Time | Recourses |
|---|---|---|
| SECTION 0: Introduction to the Pilot Course<br><br>• Welcoming message to the course explaining the reasoning behind the pilot lecture, the structure and contents of it<br>• Exposure to Motivational Incentives<br>• Introduction in the Discussion Forum<br>• Initial Knowledge Survey | To Be Determined | |

## Module 1

### Physiology and Scientific Principles

| SECTION 1: Physiology Behind the Device | 2 hours | |
|---|---|---|
| • Electrocardiography ECG | 25 min | • Video; to learn physiological aspects in a more visual manner<br>• Pictures; for illustrative purposes<br>• Text; for explaining the concepts<br>• Quiz for assessing knowledge |
| ○ Short explanatory Reading | 5 min | |
| ○ Video Basics of ECG and Leads Placement | 8 min | |
| ○ Drag and Drop Quiz to place the leads on patient model | 5-10 min | |
| • Respiratory Rate | 20 min | |
| ○ Video The role of the lungs | 3 min | |
| ○ Reading Explaining Pneumography | 10 min | |
| ○ Quiz related to questions from materials | 5-10 min | |
| • Pulse Oximetry | 15 min | |
| ○ Video Clinical Skills for Pulse Oximetry | 5 min | |
| ○ MC Quiz related to questions from the video | 5-10 min | |
| • Blood Pressure | 25 min | |
| ○ Video to understand how does BP work | 5 min | |
| ○ Video Clinical Skills for BP Assessment | 8 min | |
| ○ True/False Quiz related to questions from videos | 5-10 min | |
| • Body Temperature | 25 min | |
| ○ Video Clinical Skills for Temperature Assessment | 8 min | |
| ○ Reading Summary of the key ideas from the video | 5 min | |
| ○ Quiz related to questions from videos | | |
| • DIY Experiments: Measure owns Pulse, Respiratory Rate and Temp | | |

## Module 2: Maintenance/diagnosis/repair of Diagnostic Medical Equipment

### Patient Monitor

| SECTION 2: Basics of Patient Monitor – Device and Components | 30 min | |
|---|---|---|
| • Health Problem Addressed and Environment of Use | 5 min | • Video; to show a real-life Patient Monitor<br>• Pictures; for illustrative purposes, system diagram<br>• Text; for explaining the concepts<br>• Quiz for assessing knowledge (Components Device)<br>• Peer review platform to grade drawings |
| ○ Short explanatory reading with figures | | |
| • Product Components and Relationship to Physiology | 30 min | |
| ○ Video (showing the device and all its components, including explanation of its functionalities): Overview, ECG Monitoring, Respiration Monitoring, SpO2 Monitoring, BP Monitoring | 25 min | |
| ○ Short Quiz (making them name a few components from the videos) | 5-10 min | |
| • Device Workflow | 10 min | |
| ○ Drag and Drop to order the Operating Steps based on student's intuition (self-evaluated) | 5 min | |
| ○ Figure showing the correct steps | 5 min | |
| • System Diagram | 13 min | |
| ○ Photo + Explaining text (System diagram visualised and built in a video where the diagram is explained) | 5 min | |
| ○ Draw (Exercise where participants have to draw the system diagram - peer reviewed) | 8 min | |
| **SECTION 3: Preventive Maintenance** | **~30 min** | |
| • Preventive Maintenance | | • Photo of Patient Monitor, from different angles<br>• Discussion board, linked to exercise<br>• Wiki access, linked to exercise<br>• Correct and complete checklist, as feedback |
| ○ Create preventive maintenance plan (Based on a photo of the Patient Monitor; specific model of which manual can be found easily, the participant needs to create preventive maintenance checklist) | 10 min | |
| ○ Share & Comment (share the checklist in the discussion forum and comment on others) | ?? min | |
| ○ Create one checklist (Together with 3 others, create a complete checklist in Wiki) | ?? min | |
| ○ Improve and adjust checklist (Based on a correct and complete checklist provided, adjust and finalize the checklist - also show how the manual could have been found) | 10 min | |

| | | |
|---|---|---|
| SECTION 4: Troubleshooting, Repair & Testing<br><br>• Troubleshooting/Diagnosis, repair & testing<br>  ○ Introduction video explaining how to handle in case the Patient Monitor is not working. So quickly discuss the checklist of troubleshooting, manners to repair and how to test. Short, only functioning as introduction.<br>  ○ Stepwise checklist and introduction (Provide participants with a stepwise checklist of possible steps to troubleshoot, repair and test for them to consult)<br>  ○ Work together in the discussion forum Interactive image of a broken device, which must be repaired. By (1) diagnosing error must be detected, (2) correct solution for repair must be selected (three possibilities provided, only 1 is correct), (3) testing steps must be selected out of long list (multiple answers can be correct). Adjust by feedback provided directly | **60 min**<br><br>**60 min**<br>7 min<br><br>3 min<br><br>50 min | • Video (explaining troubleshooting of a Patient Monitor)<br>• Checklist (troubleshoot checklist)<br>• Interactive image (including feedback build in by the system when selecting incorrect option)<br>• Discussion board linked |
| SECTION 5: Final Assessment – Complete Case<br><br>• An interactive photo of a Patient Monitor is provided in which students must complete assignments:<br>  ○ provide correct information about physiology and function of the component<br>  ○ explain certain chain reactions by selecting the correct part of the system diagram<br>• An interactive photo of a broken Patient Monitor is provided, the students must:<br>  ○ Create preventive maintenance checklist<br>  ○ Solve an error by (1) diagnose error, (2) repair the device, (3) test | **60 min**<br><br>**20 min**<br><br>10 min<br><br>10 min<br><br>**40 min**<br><br>10 min<br>30 min | • Interactive Photo 2x |
| SECTION 6: End of Pilot Course<br><br>• Feedback on the Course | To Be Determined | |

The above given storyboard was created before starting the design process in edX Edge. So as visible, some adjustments were made with regards to the actual Pilot Course and the above given storyboard. As described earlier, we will only elaborate in detail on sections 0, 3, 4, 6 and parts of section 5. As visible compared to the described setup for the Pilot Course in Chapter 3, section 0 has not been adjusted.

Section 3 has been changed slightly; it was recommended for this setup by the edX support team not to request collaboration between participants. Due to small sample sizes and different time zones of participants, this could cause congestion. Therefore it was decided to maintain a similar setup, in which participants had to create their own checklist, however interaction was limited to posting and reacting in the discussion board. Participants had to verify their checklist themselves with a provided complete and correct checklist.

Section 4 was drastically changed, mostly due to similar reasoning as Section 3. In addition the section was split up into three separate sections. This was also recommended by the edX support team, since it is recommended to keep pages within the platform relatively short. Participants tend to stop scrolling if pages are too long. Whilst adjusting the setup it was aimed to maintain an equal variation of colouring. The sections became as follows:

| | | |
|---|---|---|
| SECTION 4: Troubleshooting, Repair & Testing<br><br>Troubleshooting<br>• Explanatory text with photos explaining the concept, why it is relevant and how to troubleshoot. Also giving common errors as example.<br>• Explanatory Video to further explain and visualize practical side of the theory<br>• Multiple Choice question<br>• Drag and drop questions<br><br>Repair<br>• Explanatory text with photos explaining the concept and how to perform repair. Also giving common errors and repair process as example.<br>• Explanatory Video to further explain and visualize practical side of the theory<br><br>Testing<br>• Explanatory Video to explain and visualize the theory, video was decided as method since testing is complex and practical. This could best be explained in a video. | To Be Determined | |

Visible is that only the first section contains questions, however these questions cover topics on repair and testing as well. This setup requires active learning from participants. In addition it created a guided learning environment, being exposed to questions prior to theory enables more focused learning of the theory.

Section 5, the Final Assessment, was changed completely. The Final Assessment in the Pilot Course existed of a variation of question types; (1) multiple choice, checkboxes, drag and drop and open questions. Based on pre surveys it was concluded a complete case would make the required time to complete the Pilot Course too long. In addition, the platform does not allow for such a setup. And lastly, this research was limited to recourses, knowledge and time not enabling the development of a complete case. By variating the question type and manner of questioning, the same goal was aimed to be reached; test all knowledge and capabilities in different manners. This enabled a fair judgement of assessment results, were the bias of being better at manners of learning was eliminated.

Section 6 remained as originally designed, only a closing note was added.

When analysing the storyboard in order to setup a design for the final MOOC, several adjustments and recommendations should be mentioned. First of all total time must be better considered; the above setup content is too time consuming. Ideally one section is finalized per week, covering multiple devices, for which participants indicated they are willing to dedicate 4-6 hours on a MOOC per week.

Secondly, are technical limitations; drag and drop exercises give limitations to participants accessing the course from a mobile phone. These limitations do not occur when using a computer or when accessing via the application instead of a web browser, however when implementing drag and drop exercises this must be considered. Similar technical limitations might occur when implementing interactive images or case assignments, this must be tested.

The discussion form was used by most participants in the Pilot Course just as the BMET library, referred to in the storyboard as Wiki, and participants reacted really positive on both. They indicated a network could be created with the discussion board and information found with the BMET library. So my recommendation is to include both in the MOOC and to have participants maintain access after finalizing the training. This would provide participants with a permanent network and platform of information.

Videos were received better than textual descriptions, so my recommendation would be to limit explanations with text and images and to maximise the use of short videos. Especially when explaining practical skills videos appeared to be more successful.

With regards to exercises participants indicated they appreciated to have exercises after theoretical explanations. This allowed them to immediately test and verify knowledge learned. In addition they indicated a varied set of exercises in desired.

In conclusion, the storyboard provided above, including my recommendations and learnings, forms a good basis for the development of a MOOC.

## C.2. Blueprint MOOC

When creating the blueprint, a set template was used and filled in. This template and its setup are given below. The blueprint was created for the final MOOC, therefore this section will elaborate on the blueprint as setup for the final MOOC, which is already adjusted according to recommendations based on the results of this research. The blueprint will discuss learning objectives, first general for the complete MOOC, followed by specific learning objectives per module. In addition this blueprint will elaborate on assessment methods.

**Learning objectives - general**

The participant is able to...

- Understand the responsibilities and tasks of a BMET
- Understand the relevance of an active and efficient BMET within a hospital
- Perform preventive maintenance, troubleshoot, repair and test of/on medical equipment (diagnostic, therapeutic, analytical and general)
    - Understand the importance and relevance of preventive maintenance, repair and testing
    - Understand set criteria based on standards
    - Differentiate between the equipment types
    - Be able to locate the information to help them with that specific equipment (in cases where they don't have the documents because equipment comes from different countries)
    - Understands what to do, with what frequency and in what order and is capable to complete multiple repairs – on many different kinds of devices.
- Perform his/her role in a better way; decrease the number of out of service medical and laboratory equipment and decrease the duration of equipment being out of service
- Take up more responsibility, this could raise the position of the BMET and gave greater recognition.
- Coach medical staff in equipment use training.
- Advise medical equipment management (to view different aspects than clinicians).

**Learning objectives - specific**
**COURSE 1 Basics of Biomedical Equipment Maintenance for BMETs.**
Module 1: Health Technology Management

- Understand the role of Health Technology Management practices and equipment life cycles in low resource settings.
- Understand the role of preventive maintenance and repair of medical equipment in low resource settings.
- Understand the importance of standardization of equipment.
- Understand the importance of good, accurate inventory management.
- Have good knowledge of job description and responsibilities and understand importance of the role of a BMET within a hospital
- Understand potential consequences of being successful and of failing
- Is aware of set measurable goals to measure own performance

Module 2 Preventive maintenance of medical equipment in low resource settings

- Understand importance of preventive maintenance
- Is capable of Risk assessment; coupling maintenance to patient safety risk.
- Setting up preventive maintenance programs, procedures, and schedules based on risk assessment.
- Aware and capable of collecting the resources needed for preventive maintenance
- Using the inventory and keeping records
- Basic general principles and good practices of maintenance, e.g.: safety testing, calibration, inspection, recording work, verifying settings with users after maintenance.

Module 3: General working principles of medical equipment in relation to human physiology

- Diagnostic equipment, e.g.: pulse oximeters, patient monitors, etc.
- Therapeutic equipment, e.g.: life support equipment, surgical equipment, etc
- Analytical equipment, e.g.: laboratory equipment, etc.
- Miscellaneous equipment and processes, e.g.: sterilization equipment, medical waste management

Module 4: Supporting topics

- Clinical user instruction/training
- Patient safety and hygiene
- Technical specifications
- Inputting in procurement process
- Regulations for medical devices
- Learn how to use Google, Google Translate and YouTube to get access to user manuals/maintenance and repair guidelines
- Available information on medical devices from WHO.

After finishing this programme learners are able to understand the working principles of most medical equipment, are able to manage the health technology in the hospital as well as give input to the hospital’s procurement process, are able to find information on medical devices using online resources and understand the job description and responsibilities and the relevance and importance of the tasks.

**COURSE 2: Maintenance and repair of biomedical equipment**

Module 1: General engineering skills and good practices

- Electronic circuits and drawings
- Electronic equipment (basic principles of biomedical electronics)
- Engineering mathematics
- Data communication
- Electronic controllers
- Logic circuits
- Measuring instruments
- Using the inventory and keeping records
- Rationale and basic general principles and good practices of maintenance, e.g.: why preventive maintenance, safety testing, calibration, inspection, recording work, verifying settings with users after maintenance.

Module 2: Maintenance/diagnosis/repair of Diagnostic medical equipment (e.g. pulse oximeters, patient monitors) in low resource settings (for each core equipment)

- Equipment X
    - Preventive maintenance
    - Troubleshooting/Diagnosis
    - Repairing
    - Testing

Module 3 Maintenance/diagnosis/repair of therapeutic medical equipment (e.g.: life support equipment, surgical equipment, electrosurgical equipment, etc) in low resource settings (for each core equipment)

- Equipment X
    - Preventive maintenance
    - Troubleshooting/Diagnosis
    - Repairing
    - Testing

Module 4 Maintenance/diagnosis/repair of analytical medical equipment (e.g.: laboratory equipment, etc) in low resource settings (for each core equipment)

- Equipment X
    - Preventive maintenance
    - Troubleshooting/Diagnosis
    - Repairing
    - Testing

Module 5 Corrective maintenance/diagnosis/repair of Miscellaneous equipment (e.g.: sterilization equipment, medical waste management) in low resource settings (for each core equipment)

- Equipment X
    - Preventive maintenance
    - Troubleshooting/Diagnosis
    - Repairing
    - Testing

Module 6: Supporting topics (copy/duplicate from Course 1)

- Clinical user instruction/training
- Patient safety and hygiene
- Technical specifications
- Inputting in procurement process
- Regulations for medical devices
- Learn how to use Google, Google Translate and YouTube to get access to user manuals/maintenance and repair guidelines
- Available information on medical devices from WHO.
- Using the inventory and keeping records
- Basic general principles and good practices of maintenance, e.g.: safety testing, calibration, inspection, recording work, verifying settings with users after maintenance.

After finishing this programme learners are able to diagnose and repair common problems in medical equipment in a hospital.

**[ COURSE 3 Train the trainers of BMETs. This will be a follow up course which is aimed for after successful introduction of Course 1 and 2]**

- Covering topics of course 1 and 2 in more detail, expecting knowledge of course 1 and 2 already learned.

After finishing this programme learners are able to train other BMETs to understand the working principles of most medical equipment, to diagnose and repair common problems in medical equipment in a hospital, to manage the health technology in the hospital as well as give input to the hospital's procurement process, and to find information on medical devices using online resources.

**Assessment methods**
**COURSE 1**

- MCQ - Understand working principles (checklists of diagnostic equipment)
- Role playing case study - to test managing capabilities (manage health technology + give input on procurement process)
- Open questions - provide all possibilities (channels) to find information

**COURSE 2**

- MCQ - diagnose common problems of equipment based on photos and/or videos
- Simplified version of augmented reality (interactive photos or videos of the device), case study is presented. Participants must solve the problem of the device, given by the case study - repair common problems. Student must perform correct steps in correct order by clicking correctly in the interactive photo/video – verify if this is accessible without limitations from a mobile phone with limited internet connectivity as well.
- MCQ - repair common problems, by selecting proper repair possibility of multiple answers based on photo and problem presented

Additional comments

- Assessing as described above will be done after finalizing the course
- During the course, students must perform similar assessment exercises as practice material, in which they can use the discussion board to provide and request help from other participants
- Exercises during the course will be provided with direct feedback. When an answer is incorrect, additional exercises, split up into more detailed steps (helping the participant along the procedure more stepwise) will be presented
- Discussion boards will be closed during the Final Assessment, to test the knowledge of that participant. However collaboration and social contact will be encouraged throughout the course.
- Access to the discussion board will remain open after finalizing the course, in order to help other participants or request help with real life questions

# Appendix D

## Pilot Course

This appendix will elaborate in more detail on the content and setup of the Pilot Course, designed as the first step in the development of a final MOOC to train Biomedical Equipment Technicians. As explained before, the content and setup are based on the content and setup of the MOOC as described in Appendix B. However, only a small part of that design is used in this Pilot Course. The Pilot is mainly based on Course 2, Module 2 of the final MOOC, zoomed in at the Patient Monitor as selected device. However, Course 1 of Module 2 is also partly used, to educate participants with the required physiology knowledge applied to the Patient Monitor. Below, a detailed description and visualization of the Pilot Course is given.

The Pilot Course is developed in edX Edge, which can be accessed via smartphone, tablet or computer. After registering, the overview page of the course looks as follows:

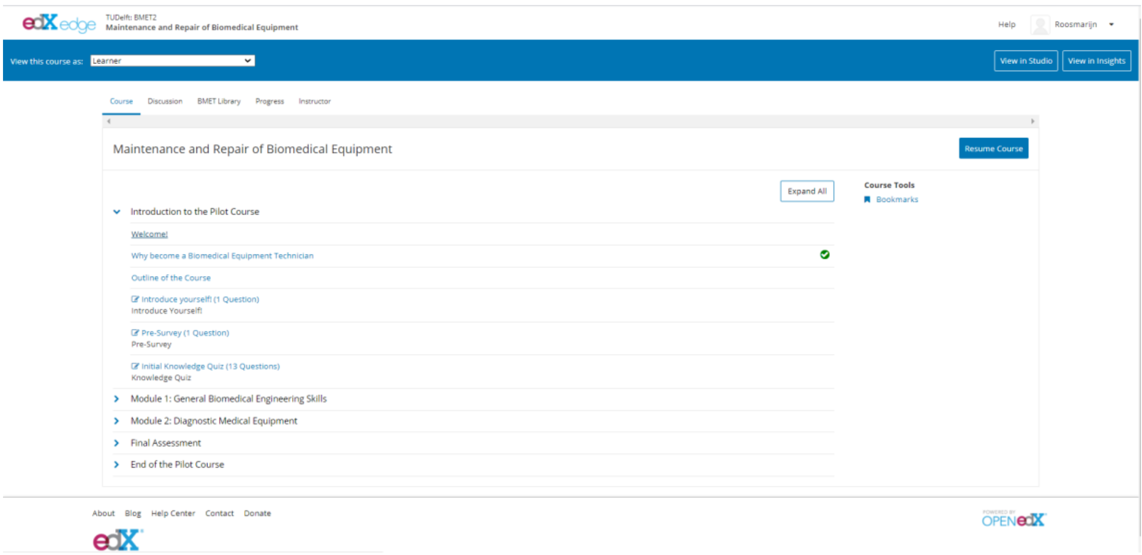


FIG. D.1 Overview of the Pilot Course in edX Edge.

The course begins with the section 'Introduction to the course' and the specific part 'Welcome!'. This part contains introductory messages, initializing the actual course. So a general message, explaining the course the participant has initiated, an introduction to the lecturers and some technical notes and recommendations.

The second part of 'Introduction to the Course' is 'Why become a Biomedical Equipment Technician'. This part is implemented to answer the research question. Only half of the participants will be exposed to this part, the half referred to as 'Exposed Group'. The other half, referred to as 'Not Exposed' will only see a very short description of the importance of the job. This short description reads as follows:

***Importance of Biomedical Equipment Technicians***
*Hospital staff all around the world should have at least one Biomedical Equipment Technician (BMET). It is the responsibility of the BMET to increase the lifetime of equipment by performing preventive maintenance and to repair broken equipment.*

*The hospital can only assume properly working equipment if a Biomedical Equipment Technician is present as hospital staff and working with a motivated attitude*.

Participants from the 'Exposed Group' will additionally to the above given text, be exposed to a job description, summarizing all responsibilities of a BMET and to a motivational video. The job description is formulated as follows:

***Job description BMET***
*In order to become a Biomedical Equipment Technician, you must understand the tasks and responsibilities of a BMET. Here is a brief summary of the tasks and responsibilities of the job.*

*Responsibilities and tasks of a Biomedical Equipment Technician*
- *Develop/ maintain inventory of the Biomedical equipment*
- *Develop a preventive maintenance (PM) schedule, conform standard guidelines and perform the PM accordingly*
- *PM should be performed according to the standard checklist. The Checklist should include:*
  - *Tidiness of the equipment*
  - *Functional checks*
  - *Safety checks*
  - *Integrity of accessories*
  - *Maintain log*
- *Perform corrective maintenance as required, which includes:*
  - *Troubleshoot to determine the error*
  - *Repair the error*
  - *Perform safety test and function test after repair*
  - *Maintain log*
- *Perform user's training on Biomedical equipment for clinical staff and support staff*
- *Provide technical input to hospital management on purchasing, commissioning, decommissioning and disposal of biomedical equipment.*
- *Ensure minimum stock of frequently required consumables and spare parts (including batteries, cleaning material etc).*

This job description is formulated in collaboration with the Nick Simons Institute in Nepal, to guarantee the description is in line with local standards and expectations.

In addition to the job description, the Exposed Group is exposed to a motivational video, also created in collaboration with the Nick Simons Institute in Nepal. In the video a successful Biomedical Equipment Technician, named Mr. Uttam Pokhrel, explains his role and the importance of his job. The video emphasizes the relevance of his job and the recognition he receives when being successful. This is also stated by his manager in the video, who explains how grateful he is to have Mr. Uttam Pokhrel in his team, especially since Mr. Uttam Pokhrel is performing so well. The video must excite intrinsic motivation among participants and thereby result in better performance in the Pilot Course and a higher completion rate. Below a visualization of the video is given in Figure D.2, subtitles where synchronized with the video to improve clarity of the video.

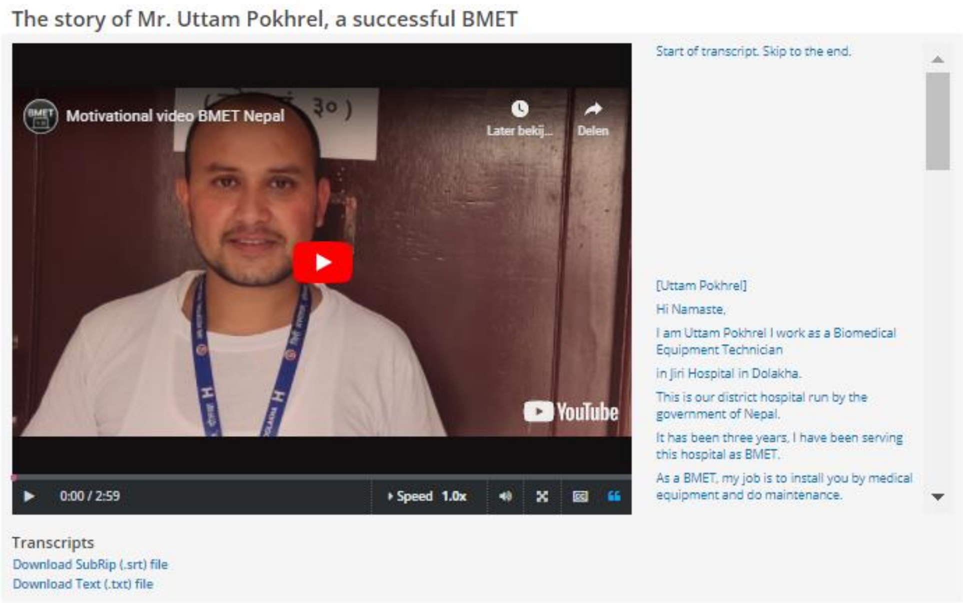



FIG. D.2 Motivational Video

After the part of why become a BMET, the 'Introduction to the Course' provides a course outline; each module is briefly explained. In addition, the BMET library added to the course is introduced as visible in Figure D.3 below. The BMET library is a page inside the Pilot Course, giving access to some useful documents functioning as an example of how-to lookup information and to give direct information. The library is visualized in Figure D.4 below.

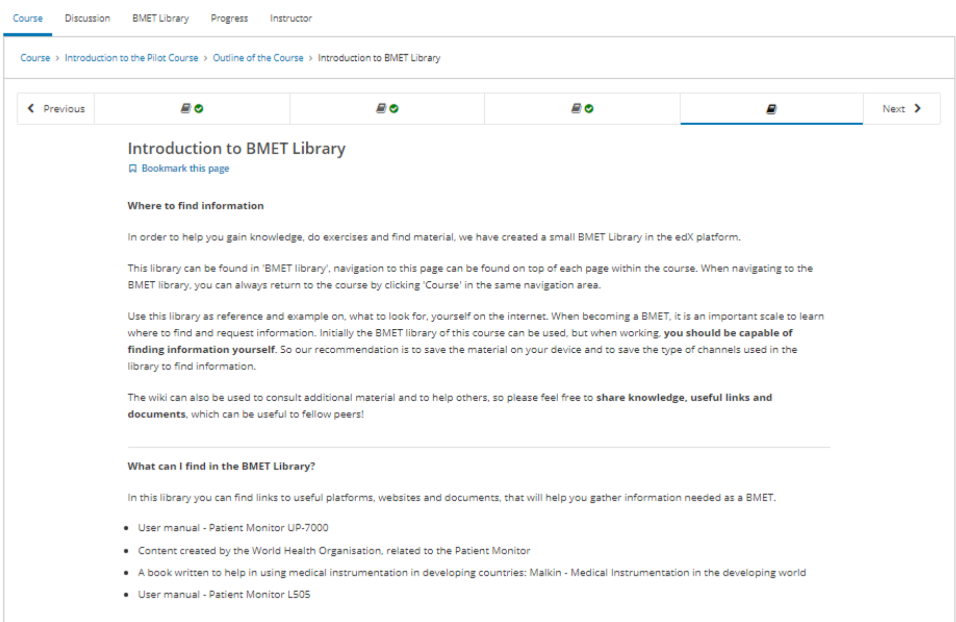



FIG. D.3 Introduction to the BMET Library inside the Pilot Course.


FIG. D.4 The BMET Library inside the Pilot Course

The Introduction section continues with a discussion board, requesting participants to introduce themselves. This discussion board is meant for participants to interact with other students. It will allow the exchange of knowledge, it will form a platform of information and a platform where participants can request but also provide help. Figure D.5 below visualizes the discussion board.

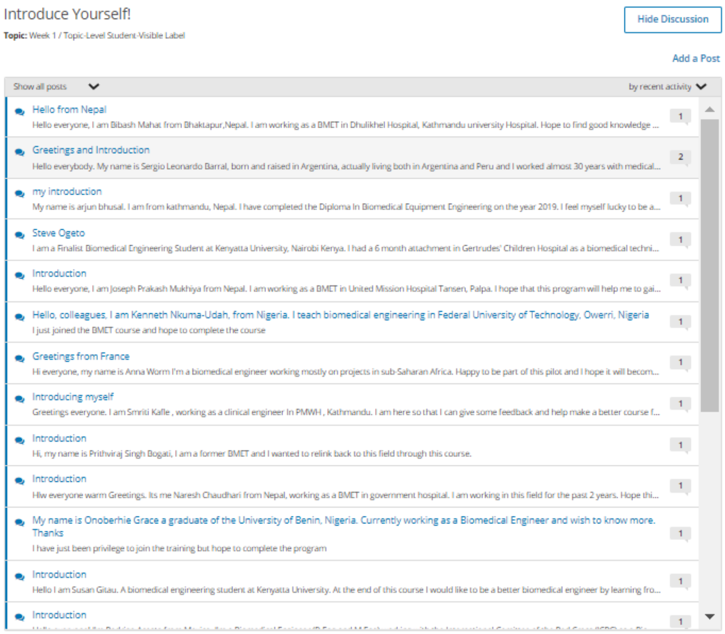



FIG. D.5 The discussion board 'Introduce Yourself!'

The second to last part of the introduction section is the request to participants to fill in a survey. Details and content of all surveys can be found in Appendix E.

The introduction section ends with a knowledge quiz. This quiz exists of questions about the topics discussed in the Pilot Course and is meant to measure the starting level of participants. At this point, participants are not expected to know anything about the topic or expected to be capable to perform certain assignments. However, some participants do have prior experience from training or work. In order to analyse the improvement made in this course, prior knowledge and acquired knowledge will be compared, therefore participants are asked to complete this quiz. In order to analyse performance without guessing chance, the answer 'I do not know' was added to all questions. This will be marked incorrect, but it was requested to choose that answer over guessing. That will give honest results to this research. Guessing will bias this research.

The Knowledge Quiz exists of five parts; (1) Knowledge Quiz – Job Description, (2) Knowledge Quiz – Anatomy and Physiology, (3) Knowledge Quiz – Patient Monitor, (4) Knowledge Quiz – Preventive Maintenance and last (5) Knowledge Quiz – Troubleshoot & Repair. These topics will be discussed throughout the course and again tested in the Final Assessment.

After the introduction section, the course will start with 'Module 1: General Biomedical Engineering Skills'. After a brief introduction, five physiological topics are discussed; (1) The Cardiovascular System, (2) The Heart and Electrocardiography ECG, (3) Blood Vessels and Blood Pressure, (4) The Respiratory System and last (5) Body Temperature. Which is followed by a closing section. Each section contains a combination of theory and questions. The first section; 'The Cardiovascular System' is visualized below in Figure D.6 as example.

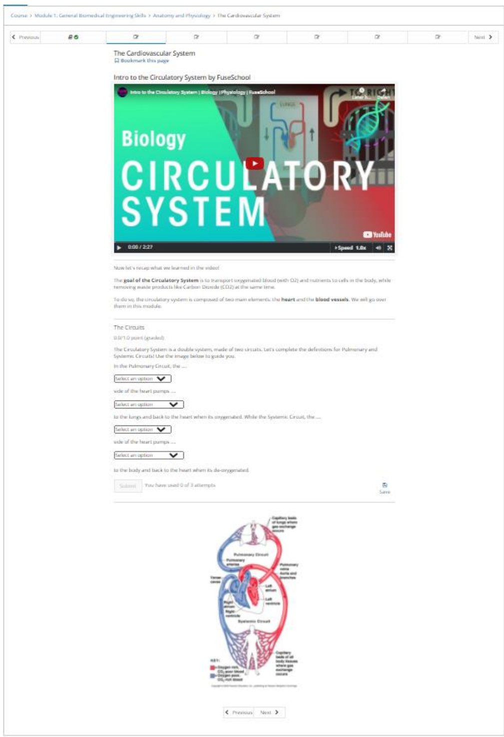



FIG. D.6 Module 1: General Biomedical Engineering Skills – Anatomy and Physiology - The Cardiovascular System

After Module 1, the core of the Pilot Course initiates; 'Module 2: Diagnostic Medical Equipment'. This module exists of five sections all elaborating on the Patient Monitor. Each section was already briefly explained in the main text, however additional information and mostly visualization is given in this appendix. The five sections of this module are as follows; (1) Device and Components, (2) Preventive Maintenance, (3) Troubleshooting, (4) Repair and (5) Testing.

The first section 'Device and Components' exists of seven subsections; an introduction to the Patient Monitor, the block diagram, four technical components and an ending to this section. Each section is built up out of a combination between exercises and theory. As example, the subsection 'Patient Monitor: System Block Diagram' is visualized in Figure D.7 below.


FIG. D.7 Module 2: Diagnostic Medical Equipment – Patient Monitor.I – Device and Components – Patient Monitor: System Block Diagram

The second section 'Preventive Maintenance' requests the participants to create a preventive maintenance checklist themselves, before being exposed to theory. A brief introduction explains the importance and setup of a preventive maintenance checklist in general. This is followed with a detailed description of the exercise. Subsequently, participants are requested to share their checklist in the discussion board. This must encourage participants to cooperate, share and request knowledge and make use of available platforms and channels. A visualization of the discussion board with the checklists is given below in Figure D.8.

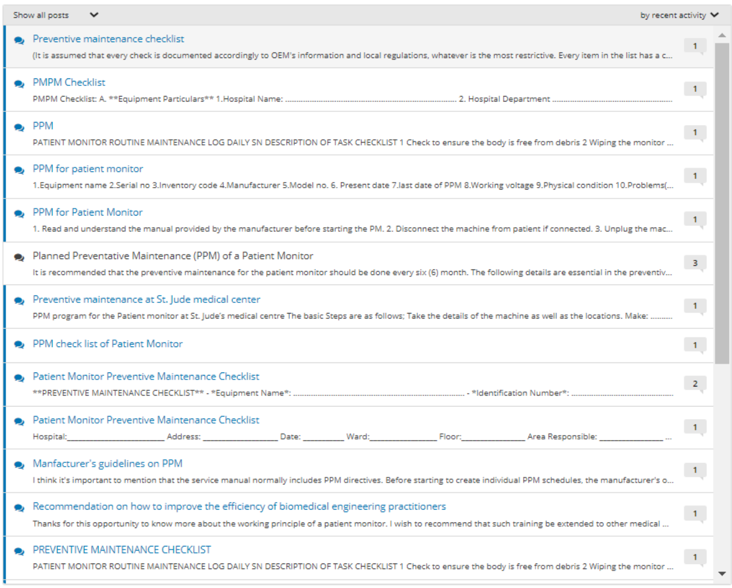



FIG. D.8 Discussion Board – Uploads created Preventive Maintenance checklists.

Subsequently, participants can correct their personal preventive maintenance checklist. A very detailed correct preventive maintenance checklist, including explanation on how to perform maintenance is provided.

In the third section of Module 2; Troubleshooting, common errors are elaborated on and explained how to be detected. The section first explains most common errors in theory and the section is ended with a number of exercises in which participants have to troubleshoot errors themselves. The exercises also contain brief introductions to the following sections; repair and testing. An example is visible below in Figure D.9, where participants have to select the correct solution to a problem questioned the previous exercise.

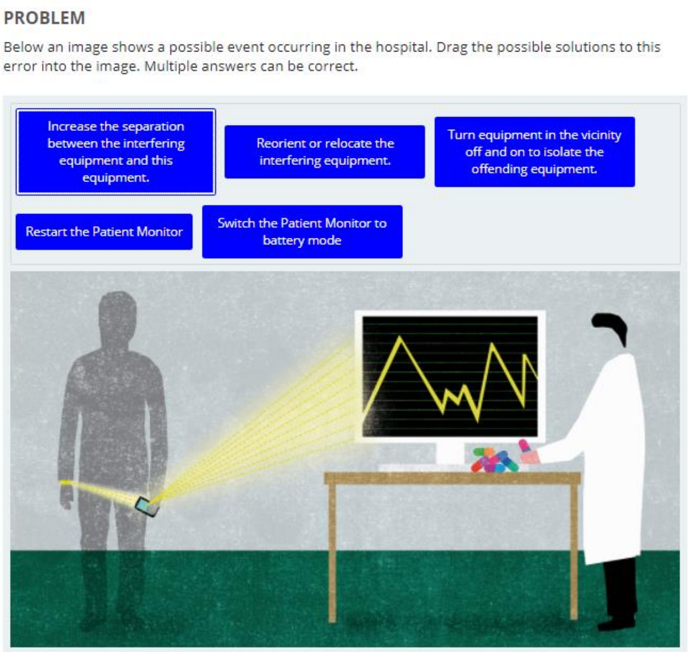



FIG. D.9 Example problem of the section Patient Monitor.III – Troubleshooting.

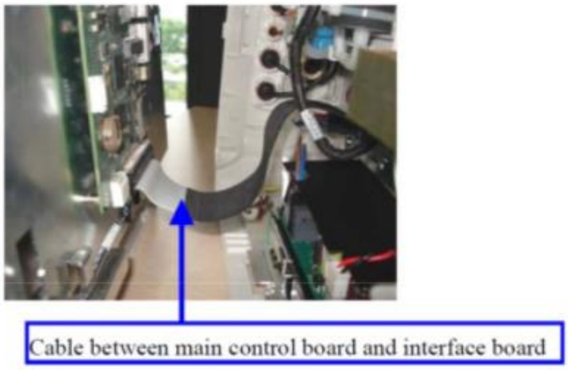
In the section 'Repair' the course explains how to dissemble the Patient Monitor, this is done by text, photos and video, to visualise and thereby mimic real-life lessons. This section is created together with the Nick Simons Institute in Nepal. The explanation by photos is visualized as example, in Image D.10 below. Beneath that image, an example image showing the different components inside the Patient Monitor is visualized in Image D.11.

**Disassembling the Main Unit**

Separating the Front and Rear Half of the Monitor

1. Place the equipment on the work surface.
   Locate, loose and unscrew screws as shown in the image below:

2. Separate the front housing assembly and rear housing assembly with caution.
3. Disconnect the cable between the main control board and the interface board and then take off the front panel. The cable is visualized in the image below:




4. For most equipment with standard configuration, the parameter connector assembly, can be removed directly.

FIG. D.10 Explanation of how to disassemble the Patient Monitor expressed with photos.

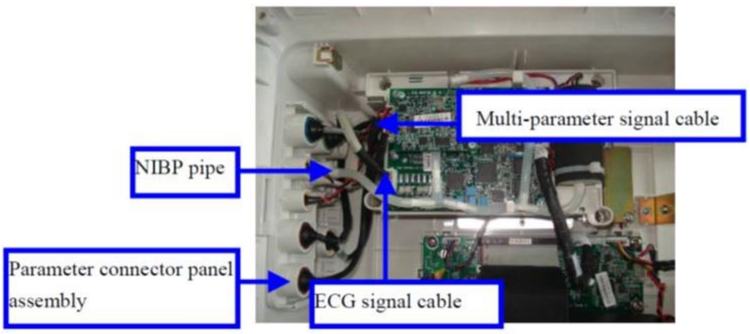



FIG. D.11 Visualization of the components present inside the Patient Monitor.

The last section, Testing, explains by video how to perform tests on the Patient Monitor, to verify if the monitor is working as required. This is visualized in Image D.12 below.

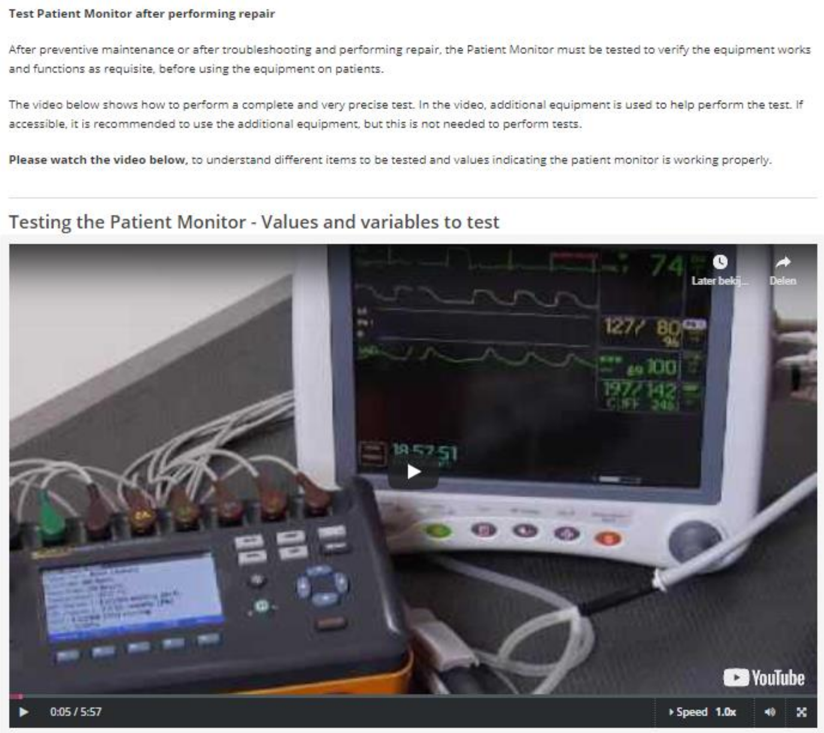



FIG. D.12 Section ‘Patient Monitor.V – Testing’ showing how to perform tests on the Patient Monitor in an explanatory video.

After the introduction and Module 1 and 2, participants have reached the Final Assessment. The Final Assessment assesses participants on all knowledge and capabilities discussed in the Pilot Course. This is done with a number of variating exercises. The Final Assessment is used to help give answer to the research question and as a data set within this research. As mentioned before, the Final Assessment consists of the same question categorization as the Knowledge Quiz. The five categorizations are as follows; (1) Final Assessment – Job Description, (2) Final Assessment – Anatomy and Physiology, (3) Final Assessment – Patient Monitor, (4) Final Assessment – Preventive Maintenance and (5) Final Assessment – Troubleshoot & Repair. Some questions overlap between the Knowledge Quiz and the Final Assessment. However, in general the Final Assessment is more complex than the Knowledge Quiz. The Final Assessment contains more open questions and the questions require more detailed knowledge. Also, the Final Assessment requests interpretation capacities rather than only knowledge reproduction. An example of this is visualized in Image D.13 showing such a question. In this question participants have to drag and drop the correct cause or solution to the right place. Therefore they have to understand the working principles of the Patient Monitor, troubleshoot the error and understand how to repair errors.

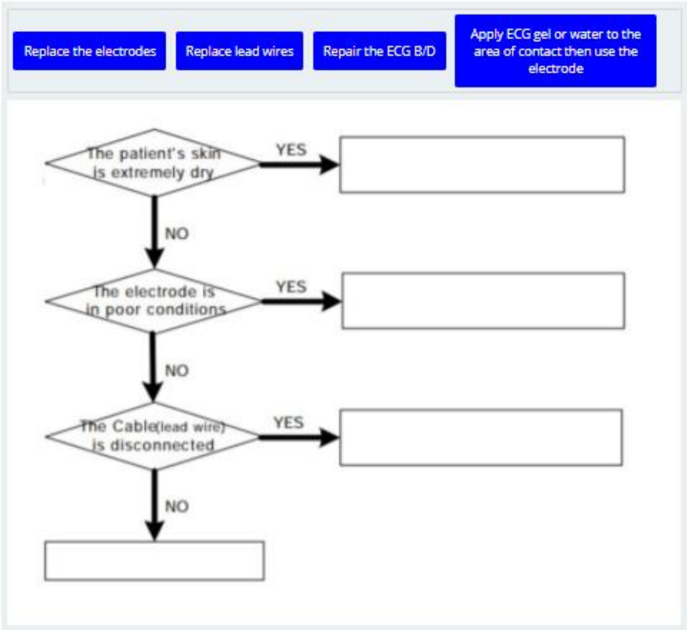



FIG. D.13 Example problem of the Final Assessment.

The Pilot Course ends with the final section; 'End of the Pilot Course'. This section expresses gratitude to the participants and requests them to fill in a feedback survey. The survey is meant to collect feedback on the complete Pilot Course and additional data on performance of the participants, like time spent on the Pilot Course. Responses will be used to improve the design and setup of this course and to gather personal information and experience. More detailed description on the use of responses and the content of the survey can be found in Appendix E.

# Appendix E

## Surveys

This appendix elaborates on all surveys used in this research. In total four surveys have been filled in by participants; (1) The Design of a BMET MOOC, (2) Pre-Survey, (3) Feedback on the Pilot Course and (4) Feedback Motivational Video. The first survey 'The Design of a BMET MOOC', was spread in order to recruit participants for the Pilot Course. In this survey, expectations and desires of potential participants where requested to help in the design of the Pilot Course. In addition participants where asked whether they would be willing to participate in a Pilot Course, and if so, email addresses where collected. The content and design of the survey can be found below.

## The Design of a BMET MOOC

Delft University of Technology, in collaboration with the Nick Simons Institute, is designing a MOOC (Massive Open Online Course) for training for Biomedical Equipment Technicians (BMET).

We would like to thank you for helping us in designing of the MOOC! This questionnaire consists of multiple-choice questions only and will take a few minutes to complete.
Before initiating actual questions, we would like to receive some information about you.

The questionnaire is anonymous; the input will be used for research purpose and further development of the training only. Answers and data concluded from this questionnaire will not be spread or used for other purposes.

Where are you currently living/working/studying? *
Image Source: European Public Health


- ◯ Africa (Blue)
- ◯ North America (Pink)
- ◯ Latin America (Pink)
- ◯ South-East Asia (Purple)
- ◯ Europe (Green)
- ◯ Eastern Mediterranean (Yellow)
- ◯ Western Pacific (Red)

What is your experience in the Biomedical Equipment Technician field? *

- Currently studying to become a BMET
- Currently working as BMET in a hospital
- Currently working as BMET in a company/organisation
- Currently working as BMET instructor
- Worked as a BMET in the past
- No experience so far
- Anders: ____

Which of the following best describes your BMET training experience? *

- Currently following a training
- Have followed and completed at least one training
- Currently working as BMET after finalizing proper training successfully
- Currently working as BMET but did not follow proper training
- No training experience so far
- Anders: ____

## MOOC Platform and Duration

The complete training will consist of two independent courses:
- Course 1 reserved for the basic theoretical concepts expected of a BMET
- Course 2 focused on maintenance and repair of diagnostic, therapeutic and analytical biomedical equipment. It will include different units for each device that present the physiology behind it, the components, preventive maintenance protocols and troubleshooting the most common issues.

It will be created on edX, a trusted platform for education and learning; the MOOC will be accessible for everyone interested all over the world.

In order to design the training as efficient as possible, we would like to request your help and input!

If participating in an online training or MOOC, which platform would you use to access the training? *

- [ ] Desktop Computer
- [ ] Laptop Computer
- [ ] Smartphone
- [ ] Tablet
- [ ] I do not have access to any of the above
- [ ] Anders: ____

Where would you access the MOOC and how reliable is the internet connection there?

| | Always with Internet access | Few hours per day | Few days per week | Long periods without Internet |
|---|---|---|---|---|
| Home | ○ | ○ | ○ | ○ |
| University/School | ○ | ○ | ○ | ○ |
| Workplace | ○ | ○ | ○ | ○ |
| Internet Cafés | ○ | ○ | ○ | ○ |
| Other | ○ | ○ | ○ | ○ |

How many hours per week would you be willing to dedicate on following an online BMET training (or MOOC)? *

- Less than 4 hours
- Between 4 - 6 hours
- More than 6 hours
- Anders:

In your opinion, what would be the desired duration for the training of Course 2? *

Please keep in mind that Course 2 will cover practical aspects of medical devices from different categories (diagnostic, therapeutic an analytical), as well as topics on physiology and electronics.

- Around 6 weeks (high intensity course)
- 7-10 weeks
- >10 weeks (slow pace, highly detailed course)
- Anders:

## Pilot Course

In the beginning of July 2020, we expect to launch a pilot version of the Course, to test and evaluate the content and manner of teaching, which will improve and give valuable knowledge for the final version.

The pilot will be a short version of the final complete course, and will contain the content related to one specific medical device only. The material will be divided into 4 sections, a final assessment, and an initial and final survey.

Please answer the following questions to help us set up the pilot course!

How many hours would you be willing to dedicate to the pilot course? *

- Less than 4 hours
- Between 4 - 6 hours
- More than 6 hours
- Does not matter
- Anders:

Would you be willing to participate in the Pilot? *

- Yes
- No
- Maybe
- Anders:

If you answered 'Yes', please type your email address below so that we can contact you when they pilot is ready!

Jouw antwoord

The second survey 'Pre-Survey' was added to the beginning of the Pilot Course. This survey questioned expectations and personal information of participants. All surveys were executed only after receiving electronic consent. Information gathered with this survey was used for research purpose only. Expectations where questioned in order to optimize the design and setup of the final MOOC and personal information was gathered to analyse trends or correlations between results and certain characteristics or prior knowledge of participants. The design and content of the survey can be found below.

# Pre-Survey

Survey prior to pilot course to become a Biomedical Equipment Technician.
The survey exists of 4 sections, but all short. Completing the survey should take less than 5 minutes.

Please provide us with your email address below. The survey will remain anonymous and for research purpose only. However, we require your email address to link the results from the pilot course to results of this survey, in order to draw conclusions in this research.

*Vereist

E-mailadres *

Je e-mailadres

Selecting the "agree" button below indicates that: *

(1) You have read and understand the above information. (2) You voluntarily agree to participate. (3) You give us permission to use your input for scientific purposes. (4) You are at least 16 years of age.

- Agree
- Disagree

## Technical Questions

In order to use feedback provided most efficiently, we would like to request practical information on the technical aspects of the course and the manner of participation

On what type of device are you following the pilot course? *

- Smartphone - Apple
- Smartphone - Android
- Smartphone - Other
- Desktop
- Laptop
- Tablet
- Anders:

If you are using your smartphone or tablet, please select how you access the pilot course:

- Webbrowser
- Application

Rate the reliability of your internet connection on the location and/or device you are using to participate in the pilot course *

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Slow, not always present and non-reliable | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | Fast, always working and realible |

## Current Situation

In order to take into account all variables when analyzing the results of this research, we would like to request some personal information

What is your age? *

- ○ 16-20
- ○ 21-25
- ○ 26-30
- ○ 31-35
- ○ 36-40
- ○ >40

What is your gender? *

- ○ Female
- ○ Male
- ○ Prefer not to answer

What is the highest degree or level of education you have completed? *

- ○ Elementary School Diploma
- ○ Secondary School (e.g. High School or equivalent) Diploma
- ○ Bachelors Degree
- ○ Masters Degree
- ○ Postgraduate/Graduates Degree
- ○ Ph.D.
- ○ Anders: ____________

If you are following or have followed BMET training, please select your experience with the patient monitor *

- ☐ The patient monitor is discussed in a training I have followed
- ☐ I am currently discussing the patient monitor in the training I am following
- ☐ In the training I am following, we have not discussed the patient monitor yet
- ☐ I have not followed any training, but I have worked with the patient monitor
- ☐ I have not followed any training and have no experience with the patient monitor

## Expectation of the course

How important are the following factors in the decision to enroll for an online course *

| | Not at all important | Slightly important | Moderately important | Important | Very Important |
|---|---|---|---|---|---|
| Potential usefulness of this course in my studies and/or career | ○ | ○ | ○ | ○ | ○ |
| Future perspectives offered/made possible by following the course | ○ | ○ | ○ | ○ | ○ |
| Interesting topic of the course | ○ | ○ | ○ | ○ | ○ |
| That the course is offered online | ○ | ○ | ○ | ○ | ○ |
| Possibilities of receiving a certificate or credentials for this course | ○ | ○ | ○ | ○ | ○ |
| Universities involved in this course | ○ | ○ | ○ | ○ | ○ |
| Duration of the course | ○ | ○ | ○ | ○ | ○ |
| Pace and flexibility offered in participating in the course | ○ | ○ | ○ | ○ | ○ |
| Language and translation possibilities | ○ | ○ | ○ | ○ | ○ |

What do you consider as the biggest challenge to successfully finalize the course? *

- ○ Allocating sufficient time and combining my participation with other life obligations
- ○ Meeting deadlines for quizzes or assessments
- ○ Using and understanding the edX platform
- ○ The internet connection
- ○ Understanding the course content and thus keeping up to the level of the course
- ○ I expect no challenges
- ○ Anders: ______________________

How many hours do you expect to dedicate to this pilot course? *

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| hour | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | hours |

What guidance or flexibility do you expect from the course? *

- ○ Set deadlines for quizzes and assessments
- ○ Recommended, but not bounded pace
- ○ No deadlines, I can work whenever I am available

What do you hope to reach or improve, by following this course? *

Jouw antwoord

The third survey 'Feedback on the Pilot Course', was also added to the Pilot Course and was filled in by all participants finalizing the Pilot Course. This survey was setup to request feedback on the Pilot Course from participants. Feedback on the design of the course, the length and level of difficulty, whether expectations where met, etc. This survey functioned to both optimize the design of the final MOOC and to analyse results of this research. The content and design of the survey can be found below.

# Feedback on the Pilot Course

Before giving us feedback on the course, please provide us with your email address below. The survey will remain anonymous and for research purpose only. However, we require your email address to link the results from the pilot course to results of this survey, in order to draw conclusions in this research.

IMPORTANT: Use the same email address you used to register in the course!

*Vereist

E-mailadres *

Je e-mailadres

ELECTRONIC CONSENT: Selecting the "agree" button below indicates that: (1) You have read and understand the above information. (2) You voluntarily agree to participate. (3) You give us permission to use your input for scientific purposes. (4) You are at least 16 years of age. *

- ◯ Agree
- ◯ Disagree

## Design and Technical setup of the Course

Could all questions be answered without technical limitations? *

- ◯ Yes, I did not experience any limitations whilst looking at the questions and whilst answering, caused by my device or the technical setup of the course
- ◯ No, I could not see the complete question in my screen
- ◯ No, had difficulties answering the question, since my device caused limitations
- ◯ No, I did not have sufficient internet connection to see the information and images provided
- ◯ No, I had trouble answering questions due to unclear formulation or setup of the question
- ◯ Anders:

If you experienced any difficulties or problems, please briefly explain what type of question caused difficulties and what the difficulties or limitations were.

Jouw antwoord

How clear where the questions formulated? *

| | 1 2 3 4 5 6 7 8 9 10 | |
|---|---|---|
| I had no idea what was expected from me and what to answer. | ○○○○○○○○○○ | I knew exactly what to do and understood the question completely. |

On a scale from 1 to 10, how would you rate the design and look and feel of this course? *

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Terrible | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | Fantastic |

## Participation in the course

Since the start of the course, how would you describe your participation level? Choose the answer that best applies to your situation *

- ○ I did not participate in this course at all
- ○ I did not participate, but I did browse around a bit
- ○ I only looked at specific parts that I was interested in
- ○ I limited my participation to assessments and quizzes
- ○ I participated, but limited my time and effort by only completing the obligated items
- ○ I participated in the course, but stopped participating along the way
- ○ I fully participated in the complete course

On a scale from 1 till 10, what overall grade would you give this course? *

1: very poor, 10: excellent

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Very poor | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | Excellent |

What was the most valuable element/resource/component in this course for you? Please explain briefly why this element and why this is the most valuable to you *

Jouw antwoord

Which aspects of this course would you like us to improve? Please explain briefly why this aspect and how we should improve *

Jouw antwoord

Which elements of the course did you use or participate in? Select all that apply *

- ☐ Reading material
- ☐ Videos
- ☐ Interactive content activities (drag and drop...)
- ☐ Assignments
- ☐ Discussion board
- ☐ Additional material provided
- ☐ Anders:

If applicable; Why didn't you use any of the above channels/material? Please explain

Jouw antwoord

Did it differ per subject/topic, whether you used all the material? *

- Yes
- No

Please explain your answer; for which elements/components/topics did you use all material and why did it differ per element? *

Jouw antwoord

## Level of the course

How would you rate the following aspects of the course? The course was.... *

| | Strongly disagree | Somewhat disagree | Neither agree nor disagree | Somewhat agre | Strongly agree |
|---|---|---|---|---|---|
| Useful | ○ | ○ | ○ | ○ | ○ |
| Unique | ○ | ○ | ○ | ○ | ○ |
| Interesting | ○ | ○ | ○ | ○ | ○ |

How would you rate the difficulty level of the course based on your previous experience? *

- Far too difficult
- Too difficult
- About right
- Too easy
- Far too easy

How would you rate the amount of work required for the course? *

- Far too little
- Too little
- About right
- Too much
- Far too much

In total, how many hours did you spend on this pilot course? *

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| hour | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | hours |

Which type of exercise did you like best? *

- Drag and Drop
- Multiple Choice
- Drop Down Menu
- Checkboxes
- Discussion board
- Anders:

Please explain your answer. Why did you like that type of exercise best? *

Jouw antwoord

How would you rate the variation in exercise type of the course? *
Were the type of exercises variate enough for you, or were they all rather similar?

- ◯ Far too little variation
- ◯ Too little variation
- ◯ About right
- ◯ Too much variation
- ◯ Far too much variation

How would you rate the amount of exercises compared to theory in this pilot course? *

- ◯ Far too little exercises
- ◯ Too little exercises
- ◯ About right
- ◯ Too much exercises
- ◯ Far too much exercises

## Future Version of the MOOC

Before you submit the feedback, we would like to ask a few questions regarding the future complete version of the BMET MOOC

Would you rather have the final version of the MOOC to be: *

- ◯ Instructor-paced (with set deadlines for Lectures and assignments)
- ◯ Self-paced (do it at your own rhythm, whenever you have time)

In your opinion, is there a particular piece of equipment/component that you believe is a must to include in the final MOOC? *

Jouw antwoord

If you have additional feedback or remarks, please feel free to share them here *

Jouw antwoord

## Current Experience

Thuis section is only relevant if you are currently working as or with Biomedical Equipment Technicians or with medical equipment. If you have no experience, please ignore this section.

What is your biggest challenge in repairing out-of-service equipment?

- ◯ Lack of tools
- ◯ Lack of spare parts or consumables
- ◯ Lack of knowledge or information how to perform the repair
- ◯ Hard to determine what the problem is, so troubleshooting
- ◯ Preventive Maintenance; I do not know what the steps are and therefore do not perform this as required
- ◯ Language, all information available is in a language I do not understand
- ◯ Communication problems within the hospital between the BMET and other staff (for example, problems with medical equipment are not communicated to the BMET)
- ◯ Anders:

What could improve your job as a BMET? Please explain

Jouw antwoord

The last survey 'Feedback Motivational Video', was sent out to all participants who were allocated to the Exposed Group and have participated in the Pilot Course. This survey was created to request feedback on the motivational video specifically. Content and design of the survey can be found below.

# Feedback Motivational Video

Thank you for participating in our pilot course.

In addition to only verifying teaching concepts and content of the course, the pilot course also analysed how to intrinsically motivate participants. This was done by showing a motivational video as introduction to the course.

Please take the time to finalize this short questionnaire and to give feedback on the motivational video.

Thank you very much in advance!

*Vereist

E-mailadres *

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Selecting the "agree" button below indicates that: *

(1) You have read and understand the above information. (2) You voluntarily agree to participate. (3) You give us permission to use your input for scientific purposes. (4) You are at least 16 years of age.

- Agree
- Disagree

Did you watch the motivational video of Mr. Uttam Pokhrel (see image below)? *

The story of Mr. Uttam Pokhrel, a successful BMET


Start of transcript. Skip to the end.

[Uttam Pokhrel]
Hi Namaste,
I am Uttam Pokhrel I work as a Biomedical Equipment Technician
in Jiri Hospital in Dolakha.
This is our district hospital run by the government of Nepal.
It has been three years, I have been serving this hospital as BMET.
As a BMET, my job is to install you by medical equipment and do maintenance.

Transcripts
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- No, I have not watched the video
- I started the video, but did not watch until the end
- Yes, I have watched the complete video

If you indicated 'no' or 'only started', please explain why *

Jouw antwoord

Please rate the video on the following aspects *

| | Completly disagree | Disagree | Neutral | Agree | Completely agree |
|---|---|---|---|---|---|
| Inspirational | ◯ | ◯ | ◯ | ◯ | ◯ |
| Credible | ◯ | ◯ | ◯ | ◯ | ◯ |
| Interesting | ◯ | ◯ | ◯ | ◯ | ◯ |
| New information | ◯ | ◯ | ◯ | ◯ | ◯ |
| Clear | ◯ | ◯ | ◯ | ◯ | ◯ |

Please rate the video on the following technical aspects *

| | Bad | Medium | Good |
|---|---|---|---|
| Video Quality | ◯ | ◯ | ◯ |
| Sound quality | ◯ | ◯ | ◯ |
| Subtitle quality | ◯ | ◯ | ◯ |
| Structure | ◯ | ◯ | ◯ |

How would you rate the length of the video? *

◯ Far too short
◯ Too short
◯ About right
◯ Too long
◯ Far too long

Please rate the impact of the video on your motivation to successfully finalize the pilot course *

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lost my motivation by watching | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | Got motivated by watching |

Please explain your answer *

Jouw antwoord

What part of the video did you like best? *

◯ The Biomedical Equipment Technician
◯ The Manager

Please explain your answer *

Jouw antwoord

Please share additional comments or feedback *

Jouw antwoord