An evaluation of the knowledge and skills gained by Ethiopian participants during a short-term molecular biology and bioinformatics course

R. Downs, Dr. W. Hutchins, L. Allen, Dr. J. Hatfield, Dr. L. Gedamu, Dr. A. Aseffa, Dr. G. van Marle

Abstract

Background: Low- to middle-income countries (LMICs) like Ethiopia often do not have the educational resources needed to perform health research. In 2011, the University of Calgary (UofC) in collaboration with the University of Gondar (UofG), delivered a short-term course on molecular biology and bioinformatics to at the UofG. Evaluation of such programs is needed to promote their adaptation to the challenges of utilizing classroom knowledge within local health and research systems. This study evaluates the knowledge gain and skill use of the course participants (CPs).

Methods: A questionnaire developed from a 2010 pilot project and a focus group was conducted with the 2011CPs. A retrospective questionnaire was administered to 2010 CPs.

Results: 2010 and 2011 participants anticipated that they would use what they learned in the course more than they did in reality. One of the biggest barriers to applying knowledge and skill was material shortages. By understanding participants' long-term knowledge use, the course's curriculum may be adjusted so future programs deliver information most needed by course participants.

Background

The quickly advancing yet often uneven global development of information and communication technologies has contributed to an increased "knowledge gap" between North and South nations (Habte, 1991). This gap is particularly prominent when considering that only 5% of the global health research funding is directed to investigating the diseases that affect 90% of the world's population, despite the fact that infectious diseases cause 59% of mortalities in developing countries, a rate that is at least 80% higher than that in industrialized nations (Abbasi, 2001). Investment in education and training will be a key component for nations who are trying to reduce and eliminate this gap (Crossley & Holmes, 2001).Yet, for such education to be sustainable and impactful, it must be provided in a context that matches the local needs and priorities (Lansang & Dennis, 2004). The implementation of short-term educational programs through equitable north-south partnerships has been shown to be useful in conferring scientific knowledge to LMICs such as Ethiopia (Dodani & LaPorte, 2008; Wagner, Brahmakulam, Jackson, Wong & Yoda, 2001). Since 2006, the University of Calgary (UofC), in collaboration with the Armauer Hansen Research Institute (A.H.R.I.) in Ethiopia, have worked together to develop and deliver a short-term molecular biology and bioinformatics course in Addis Ababa. Course facilitators have included UofC students, faculty and staff. Past course participants have been individuals in science-based graduate and undergraduate studies as well as staff and researchers working at A.H.R.I. Overall, participants have found the course to be beneficial in terms of increasing their knowledge of biomolecular techniques and theory. In early 2011, the course facilitation was transferred completely to faculty at A.H.R.I. Upon the request of past course participants from the University of Gondar (UofG), the short-term course was brought to the UofG in 2011, where it was implemented in conjunction with the UofG faculty and staff.

Training evaluation involves examining the learning outcomes for participants, particularly in the form of learning and increased work performance(Alvarez, Salas, & Garofano, 2004). Summative evaluations of training programs are essential to ensure their adaptation to the challenges course participants face in using the classroom knowledge within their personal work or academic environments (Wang & Wilcox, 2006). As noted by Gapp and Fisher (2006), many course evaluations within post-secondary institutional settings give only a basic assessment of students' perceptions of a course rather than an understanding of the students' learning process or the applicability of the course in relation to thier larger community. Considering this, this project aims to go beyond a simple assessment of the course itself. It intends to examine if course participants use the knowledge and skills that they have

learned in the course and if so, how these assets are implemented within the participants' communities and work environments. Specifically, the aims of this project are to:

1) Understand if the knowledge and skills acquired by course participants are used by them in their local communities and work environments.

2) Explore what factors affect the course participants' decisions to use the molecular biology and bioinformatics skills and theories that they learned in the course.

Methods

Methodology

This is a mixed-methods, exploratory study. The quantitative (questionnaire) and qualitative (focus group) methods occured sequentially and the themes from the focus group were used to further develop and inform the results of the questionnaire (Hesse-Bieber & Leavy, 2011; Patton, 2002).

Questionnaire

A quantitative questionnaire was developed from a 2010 pilot version, using feedback from previous course participants. The revised questionnaire uses closed-ended questions to address themes that pertain to the course participants' anticipated use of molecular biology skills (MbS), molecular biology theory (MbT), bioinformatics skills (BinfS) and bioinformatics theory (BinfT). A retrospective version of the questionnaire was administered to individuals who participated in the course in 2010 so as to assess their use over the past year of what they learned in the course.

Focus Groups

A focus group was used to explore current participants' perceptions of the course and to better understand why they do or do not plan to use the knowledge and skills that they learned from the course. The questions used to guide the focus groups were based off the results of a 2010 questionnaire as well as themes from interviews conducted in 2009 that examined similar questions.

Analysis

The answers from the surveys were coded, cleaned and analyzed using descriptive statistics with the assistance of SPSS software. Electronic audio recordings of the focus group were transcribed and then analyzed using thematic content analysis (Burnard, 1991). In addition to this analysis, field notes taken by the focus group facilitators were used to help clarify participant responses and to inform the themes that were developed.

Results

Questionnaire – 2011 Participants

Thirty individuals from 11 different departments at the University of Gondar participated in the 2011 short-term course. Of these individuals, 22 (73.3%) completed a questionnaire, 12 (54.5%) of which had completed a Master's degree, and 3 (13.6%) a PhD. All of the participants were teachers and/or professors, and 8 of the participants also had a career in research related activities (Table 1). See Table 1 for participant demographics.

All of the participants who completed the survey said that they did have plans to use the molecular biology and bioinformatics theory and skills that were taught in the course, and all but one participant said that they planned to use bioinformatics theory (Table 2). Specifically, it was felt that molecular biology and bioinformatics theory would be used more overall, with 54.5% and 45.5% of participants respectively, stating that they would always use this theory, versus 36.6% and the 40.9% who said that they would always use molecular biology or bioinformatics skills (Table 3).

When considering participants' work, research, personal education, and teaching goals, the majority of the participants agreed that MbS, MbT, BinfS, and BinfT would benefit these goals in some way. For all types of goals, the highest number of participants felt that overall, MbT and MbS would benefit their goals more than BinfS and BinfT. 81.8% of participants agreed that MbT would benefit their work goals (Figure 1). In terms of research goals, 90.0% of participants stated that MbS would benefit these goals, the highest level of agreement in the 4 goal categories (Figure 2). In terms of personal education goals, it

was felt that both MbT and BinfT would benefit these goals more so than MbS and BinfS (Figure 3). For teaching goals, an equal number of participants (72.7%) felt that MbS and MbT would benefit these goals, and that BinfS would benefit these goals more than BinfT (Figure 4).

In addition to looking at goals, the questionnaire also inquired about participants' comfort level when they considered teaching MbS, MbT, BinfS, and BinfT to their students or colleagues. The confidence levels reflect participants' likelihood to use MbT and BinfT, as 77.3% of participants felt very confident that they could teach MbT and 40.9% felt very confident that they could teach BinfT. Participants also felt more comfortable teaching molecular biology than bioinformatics, as only 2 participants responded that they would not feel confident in teaching MbS and no participants said that they would not feel confident teaching MbT, while 4 participants said that they would not feel confident teaching BinfS and 5 participants did not feel confident teaching BinfT (Figure 5).

The questionnaire also asked about participants' perceptions of the factors that affect their decisions to use MbS, MbT, BinfS and BinfT before and after participating in the course (Figures 6 and 7). Overall, participants felt that their lack of experience was problematic when using MbS, MbT, BinfS and BinfT before participating in the course, but that these factors decreased after taking the course. Participants (68.2%) felt that their lack of hands on experience with MbS was largely problematic compared to only 4.5% after the course. 59.1% of participants felt that their lack of molecular biological knowledge was largely problematic before taking the course and no participants felt this way after taking the course and 45.5% said that a lack of MbT was not a problem, compared to only 4.5% prior to taking the course. In terms of bioinformatics, 77.3% of participants felt that their lack of hands on experience with BinfS was problematic, compared to only 4.5% of participants after the course. Prior to taking the course, 81.8% of participants felt that getting reagents and equipment was a big problem. By the end of the course, only 59.1% of participants felt that these issues were a problem. Additionally, 77.3% of participants felt that getting finances was a big problem, which changed to 68.2% after the course. The biggest difference seen between before and after taking the course was that before the course, 16 participants felt that having a lack of trained personal to refer to was problematic, and only 4 felt so upon completion of the course, a 54.5% decrease. Generally, areas that were previously claimed to be problematic were considered to be less so after participants' completion of the course.

Questionnaire – 2010 Participants

Four (14.8%) of the 27 participants who took the course at A.H.R.I. in 2010 completed a retrospective survey. Of those 4 participants, 2 were from A.H.R.I. and one was from the UofG. The participants from A.H.R.I. both participate in a research-based occupation and the participant from the UofG was a teacher/professor. Two of the four participants had completed an undergraduate degree, and one had completed a PhD (Table 4).

Of those participants, 100.0% had a plan to use MbS and MbT, and 75.0% planned to use the BinfS and BinfT. When asked how often they, in the past year, actually used what they learned in the course, only 25.0% said that they always use MbS, and 50.0% said they always use MbT. One fourth of participants felt that MbS and MbT were not applicable to them. For bioinformatics, 75.0% of the participants said that they never use BinfS and 75.0% said that they sometimes used BinfT.

In terms of goals, 100.0% of participants said that MbS and MbT have benefited their work and educational goals and 75.0% said they have benefited their research goals. Two of the four participants felt that BinfS benefited their work and research goals, 75.0% felt that BinfT benefited their work and research goals, and 100% felt that BinfT improved their educational goals. Half of the participants felt that BinfS were not applicable to their research goals. Overall, it was noted that molecular biology was more to applicable to participants' goals than bioinformatics.

In regards to teaching what they had learned, 75.0% and 50.0% of participants respectively felt very confident in being able to teach MbS and MbT. In contrast, 50.0% and 25.5% of participants said that they did not feel confident in teaching BinfS and BinfT (Figure 11).

The survey also asked participants to consider what factors influenced their choices to use or not use MbS, MbT, BinfS or BinfT. The factor that most (75.0%) of participants said limited their ability to use MbS was a lack of financial resources (Figure 12). Lack of knowledge and lack of skilled personnel

were not a concern for 75.0% of participants when considering if they wanted to use MbS (Figure 12). For MbT, there were no major factors that inhibited participants' use of the theory. When deciding to use BinfS, lack of knowledge and lack of experience where noted by 100.0% of respondents to affect their decision (Figure 14). A variety of factors affected individual decisions to use BinfT, which included lack of physical resources, lack of facilities, lack of knowledge, lack of skilled personnel, and lack of applicability to local research priorities (Figure 15).

Focus Group

Seven participants who had completed the 2011 short-term course participated in the focus group. The focus group was facilitated by 3 Canadian instructors. From the focus group, four areas of conversation emerged that were relevant to the scope of this project: feedback on the short-term course, debate around the importance of teaching skills versus theory, and barriers and enablers participants anticipate to encounter or have encountered in the past when using the knowledge and skills they learned from the course. The majority of the focus group conversation focused on molecular biology; bioinformatics was never explicitly mentioned, although it may have been implicitly implied in some cases.

Course Feedback

Overall, participants in the focus group expressed that they enjoyed the course and learned much from it. For instance, one participant mentioned that, as an undergraduate student, he/she had only been exposed to theory and therefore, the practical aspect of the course was useful and that participant now feels that he/she has a "good knowledge" (Participant 1).

One of the biggest limitations of the short-term course that was noted by at 3 different participants was the limited amount of time allotted to complete the course. As stated by one participant "…the training needs more time. That is to make it more internalized, to put hands on the practicals, and there is also, the time. … in the future, it would be better to make it more, to take more time rather than this" (Participant 5). To remedy this, one of the Canadian facilitators suggested that future courses be three weeks long. During the first week the focus would be on the theoretical information and would be taught by Ethiopian instructors, preferably past course participants. The next two weeks would be taught by Canadian instructors and would be more hands-on and skills orientated. This idea was met with general acceptance from the assembled participants, on the condition that the dates mutually benefited both the Ethiopian participants' and the Canadian team's schedules.

Some participants expressed that they felt that there was a gap in mentally bridging the use of the techniques taught in the course to real world applications. As mentioned by one participant "Otherwise your system of handling just to, when you are giving the practicals, I try to see how you mix the solutions because I am, I plan to work in the future by myself… otherwise it becomes theoretically, for me, it is very difficult to change to practical" (Participant 2). As a Canadian instructor explained "…when we designed this course [for participants at A.H.R.I.], it was for people who knew how to do the research and the application, they didn't know the theory and tools" (Facilitator 1). At the UofG, it would appear that the situation is somewhat reverse, and that the participants are well versed in the theory and tools, but they are, in some cases, missing the link between that theory and practical application of that theory.

Teaching Skills versus Theory

Throughout the focus group, several participants discussed the importance of teaching theory of versus the practice of molecular biology techniques. Several of the course participants felt that the course should have emphasized the practical techniques instead of the theory. As one participant said "…more practical. You know this theory, we can read it in the library, or you can give [it to us in] short manuals" (Participant 2). Others felt that the theoretical part was just as important as the practical time spent in the lab, "I believe that both parts are equally important. So, just putting our hands on the chemicals without understanding the principles is not that good….But with the principle, there has to be there, it has to be there. So that everybody can understand what he is doing, what he's mixing, and he's looking at in each and every experiment. So the principal has to be there" (Participant 3). Deciding how the course should optimally divided between teaching theory and practical application is an import aspect to take into

consideration for future courses so as to make the best use of the valuable and limited time of the course participants and instructors.

<u>Barriers to Using What is Learned</u>

One of the main barriers to applying what was learned was a lack of materials needed to perform the techniques. Several reasons were given by participants as to why getting access to materials was a problem. Difficulties in purchasing materials occurred for several reasons including supply companies being unwilling to sell materials in the relatively small amounts needed by the participants, the complexities of the local and national financial systems that make ordering materials from outside Ethiopia difficult and time consuming and the fact that the individuals who do not have a background in molecular biology often are the individuals ordering the materials and therefore mistakenly order insufficient amounts of or incorrect equipment. Additionally, participants expressed that the maintenance available for their existing equipment is minimal and often poorly managed. Due to these challenges, it is difficult for participants to use and apply what they had learned in the course.

<u>Opportunities to Using what is Learned</u>

In addition to the barriers, one of the focus group participants mentioned some of the opportunities that individuals associated with the UofG have in applying the knowledge and skills that they learned from the course. These benefits included the high academic standing and diligence of the course participants as university educators and the fact that the UofG upper administration is willing to collaborate with the Canadian team to cultivate a sustainable, international education strategy. More generally, the participant noted that there are many opportunities to do molecular biology research in Ethiopia due to the high prevalence of infectious disease in the country. Such opportunities, both within the UofG as well Ethiopia on a national level, would likely promote the use of the skills and knowledge that are taught in the course.

Discussion

Anticipated vs. Actual Use

When comparing anticipated versus actual use of the knowledge and skills of participants over the past 3 years (2009-2011), the emerging trend is that participants anticipate or plan that they will use what they learn more than they actually do. Over 70.0% of participants in all years anticipate that they would use MbS, MbT, BinfS and BinfT (Figure 16). However, a year later, 60.0% or less of participants actually used MbS, MbT, BinfS and BinfT (Figure 17). It would appear that course participants are highly optimistic about how much they will use what they have learned but that realistically, they do not use this knowledge as much as they assume they will. In the literature, there was little information on students being overly optimistic about learning outcomes, but it has been noted that although science teachers are good at assessing their students' base-line knowledge, that these teachers often vastly overestimate the knowledge gain of their students after course completion (Lightman & Sadler, 1993). It is suggested that science teachers might be more effective at anticipating their students' knowledge gain if they had a better understanding of the obstacles to conceptual learning (Lightman & Sadler, 1993). Such an understanding might also be beneficial for the course participants, especially given that during the focus groups, some participants expressed that they have difficulties taking the concept(s) they learned and applying them to their research goals.

Despite the lack of predictive accuracy in overall usage, participants were fairly accurate in anticipating that they would use MbS and MbT more than BinfS and BinfT. This is discussed in greater detail later, but it would seem that participants in this sample universally felt that they would use, and then did use, MbS and MbT more than BinfS and BinfT. It is also important to note that despite the difference that exists between intended versus actual use, all course participants from all years say that they would recommend this course to their colleagues or peers. This occurs for both participants who took the course a year ago and for those participants who just completed the course. This suggests both a long-term and immediate usefulness of the course. It should be noted that such a response is not a direct measure of the usefulness of this course, but the promotion of the course by participants with different backgrounds over and extended 3 year period suggest that even if not everything that the participants

learned in the course was used by them, overall, the course is seen by participants as being a valuable experience to the extent to which participants would recommend it to their peers and colleagues.

Theory and Skills

When considering the 2011 participants' questionnaire responses, it would appear that all participants intend to use both the molecular biology and bioinformatics skills and theory that they learned in the course. This is also true for the majority of the 2010 participants. However, upon closer examination, a greater number of participants in both groups felt that they would be more likely to use, or actually used, the skills and theory less than they had originally anticipated. Specifically, participants used the theory associated with molecular biology and bioinformatics more than the skills associated with them. For the 2011 participants, this was true in regards to their work, personal education and teaching goals. The only exception was in regards to their research goals, when they then considered MbS to be more beneficial to those goals than was MbT, BinfT, or BinfS (Figure 2).

There are several possible reasons why participants feel that they would be more likely to use theory over skills. For the 2011 participants, one reason might be that as teachers, most of what they teach in their classrooms is theory-based as there little opportunity to practice or demonstrate practical applications or skills related to that theory. As one participant in the focus group commented, he/she enjoyed having the hands-on component of the course because it gave him/her the chance to do things that he/she would normally not do in a classroom setting. Another possibility for the preference of theory over skills might be due to a reason mentioned in the focus groups, that it can be very challenging for the participants to obtain and maintain the materials needed to practice the skills that they learned in the course. This challenge was echoed by the 2010 participants, 75.0% of who noted that a lack of financial resources affected their decision to use MbS (Figure 12). This lack of materials is not unique to Ethiopia and has been well documented (Acharya, Kennedy, Daar, & Singer, 2004; Black et al., 2011; Pulliainen, Enninga, Fernandez-Arenas, & Griffiths, 2007; Rosei, Vayssieres, & Mensah, 2008; Thorsteinsdottir, Ray, Kapoor, & Daar, 2011) as affecting many African nations and is severely impinging their ability to develop health technologies and research.

It is interesting to note that the 2011 participants generally felt that access to materials was a larger problem before participating in the course, when 18 participants said getting equipment and reagents was a problem and only 13 participants felt this way about reagents and equipment after participating in the course. This may be due in part to the fact that one of the goals of this short-term course was to teach participants to make their own materials (e.g.: reagents) and how to maintain their own equipment (e.g.: basic maintenance techniques). It is hoped that by instructing course participants on how to work around or work through the difficulties of gaining access to needed materials that they will have a greater opportunity to practice molecular biology skills as well as theory in the future.

The fact that theory is used more than skills was a point that was brought up often in the focus group, where there was much discussion around if future short-term courses should focus primarily on teaching theory or on teaching skills. Course participants greatly valued the hands-on, practical experience that the course offered, to the extent to which some participants felt that the course should be entirely practice based. But as others mentioned, in order to be able to truly understand what one is doing in the lab and to be able to communicate what you are doing to your colleagues, you have to understand the theory behind it.

During the focus group, a potential solution to increasing the hands-on activities while still including a strong theoretical basis for future courses was discussed. It was suggested by a Canadian facilitator that instead of holding the course for 2 weeks, it be extended to 3 weeks, with the first week consisting of theory-based classes taught by Ethiopian instructors and the remaining two weeks being practical application classes facilitated by Canadian instructors. Given that 77.3% of the participants felt confident that they could teach MbT and 40.9% felt confident that they could teach BinfT (Figure 5), it is likely that such a plan would be successful. Also, 75.0% and 50.0% respectively of 2010's course participants still felt very confident that they could teach MbT and BinfT (Figure 11), a year after participating in the course. This means that a year from now, it is likely that the 2011 participants will still feel confident in their ability to teach MbT and BinfT, so for them to instruct a week's worth of

theory-related courses would be quite feasible. Additionally, teaching the course in this way would allow for a greater tailoring of the course to participants' interests.

Applicability of Molecular Biology and Bioinformatics

In addition to the divide that exists between theory and practice, there is also a division that exists when considering molecular biology and bioinformatics. More 2011 participants responded that MbS and MbT would potentially benefit their future work, research, personal education and teaching goals than would BinfS and BinfT (Figures 1-4). Also, a larger number of the 2011 participants felt more confident in being able to teach that molecular biology and felt that their lack of knowledge and experience was less of a factor in deciding to use molecular biology than was bioinformatics. The same trends were true for the 2010 participants; it appears that they were much more likely to use MbS and MbT than BinfS and BinfT (Table 6). Additionally, in the focus groups, whenever participants spoke about using what they had learned during the course in a practical sense, their remarks were always in regards to molecular biology, never bioinformatics. It could be assumed that in some contexts, such as when participants mentioned using "practicals," they could be referring to the practical application of molecular biology or bioinformatics. However, only molecular biology was explicitly mentioned by participants and bioinformatics remained consciously absent from the conversation. This was also reflected by the 2010 participants, 75.0% of who said that they never use BinfS and 75.0% who said they only sometimes use BinfT, compared to 50% who say they always use MbS and 25.0% who always use MbT. Although BinfS and BinfT did somewhat benefit the 2010 participants' work and research goals, MbT and MbS were more likely to have impacted their goals (Figures 8-10).

There are several potential reasons why molecular biology was more likely to be used than bioinformatics. The two biggest limiting factors that affected all the 2010 participants' decisions to use BinfS were their own lack of knowledge and lack of experience in using bioinformatics. These factors, as well as lack of physical resources, lack of facilities, lack of skilled personnel and lack of applicability to local research projects affected 75.0% of 2010 participants' decisions to use BinfT. From this, it would appear that while participants are learning about BinfT and BinfS in the short-term course, their perceived lack of knowledge and lack of experience in using this information or skills prohibits them from using these learned abilities on their own after completing the course. This problem is further compounded when the participants are unable to refer to someone who knows about bioinformatics and who can answer their questions, as is noted by the lack of skilled personnel to refer to (Figures 14-15).   Given this, it would seem that although participants initially assume that bioinformatics will be useful to them, it would seem that in order to be able to regularly use this knowledge and apply these skills, there must a be a key person to refer to help bridge the knowledge gap and lack of experience participants perceive they have.

Another reason why molecular biology might be more readily used by the participants is the curriculum of the course itself. More time is spent in the course focusing on molecular biology techniques and theory than is bioinformatics techniques and theory. This in itself may gave participants a stronger foundation in MbS and MbT than BinfS and BinfT and therefore make them more likely to apply MdS and MdT in their work, research and education settings than bioinformatics.

Limitations

The main limitations of this study were in the data collection tools themselves. For instance, the complexities of the questions were difficult for some of the participants to comprehend. In the future, simpler wording should be used. Also, directions for certain types of questions, such as the before and after questions in the 2011 participants' questionnaire were not explained to the participants, which resulted in a variety of ways of respondent input. These responses then had to be re-categorized by the researcher during data analysis, which may have hampered the integrity of the data. In the future, ways in which to answer the questions should be fully explained to participants, especially novel questions types that participants may not be familiar with.

For the 2010 questionnaires, the sample sized was very small (N=4). This makes generalization from this data impossible and the input from these four participants does not necessarily represent the views of the entire 2010 cohort. Also, because the participants are asked for much of the questionnaire to

recall their use of the skills and knowledge over the past year, recall bias must be taken into consideration. Participants may or may not accurately have remembered their actual skill or knowledge use.

Also, every effort was made to accurately transcribe what the participants said during the focus group. However, given the accents of some of the participants, the white noise in the room, and the sometimes poor quality of the audio-recording, it was, at times, very difficult to understand what participants were saying and may have led to minor errors in transcribing. In the future, if more than one person could transcribe the recording and then compare their results before compiling a final transcript, greater accuracy might be achieved. Additionally, in both the focus group and the questionnaires, only the barriers to applying knowledge and skills were discussed. In the future, it may be beneficial to also consider what opportunities actively promote individuals to apply the skills that they have learned, along with the barriers that prevent their application.

Conclusion/Future Directions

In summary, this report considered how 2010 and 2011 participants in a short-term course used the molecular biology and bioinformatics skills and theory that they learned from the course and the barriers and enablers they face in using and applying the knowledge. It would appear that participants anticipate that they will use what they have learned more than they actually apply it. When they do apply what they have learned, participants are more likely to use molecular biology skills and theory than that of bioinformatics skills and theory. One of the biggest factors that influenced participants' ability to apply what they learned was a lack of materials, which is in turn caused by supply, financial and maintenance issues that are both local and national concerns. It is hoped that by continuing the short-term course, course participants might become more innovative and self-reliant and be able to produce the materials that they need and apply more of what they learn from the course. It is also hoped that by teaching others, particularly teachers and professors, in future courses, that the knowledge gained in this course may be passed on in a sustainable manner. In building such sustainability, it is hoped that the knowledge gap between North and South nations may be reduced and that researchers in LMIC nations like Ethiopia can be empowered to increase local research and tertiary education capacity and thereby reduce the burden of poverty and disease in their local communities.

References

Abbasi, K. (2001). Progress is slow in narrowing the health research divide. *British Medical Journal, 323* doi:10.1136/bmj.323.7318.886

Acharya, T., Kennedy, R., Daar, A. S., & Singer, P. A. (2004). Biotechnology to improve health in developing countries - A review. *Memórias do Instituto Oswaldo Cruz, 99*(4) doi:10.1590/S0074-02762004000400001

Alvarez, K., Salas, E., & Garofano, C. M. (2004). An integrated model of training evaluation and effectiveness. *Human Resource Development Review, 3*(4), 385.

Black, R., Fava, F., Mattei, N., Robert, V., Seal, S., & Verdier, V. (2011). Case studies on the use of biotechnologies and on biosafety provisions in four african countries. *Journal of Biotechnology, In Press, Corrected Proof*

Burnard, P. (1991). A method of analyzing interview transcripts in qualitative research. *Nurse Education Today, 11*, 461.

Crossley, M., & Holmes, K. (2001). Challenges for educational research: International development, partnerships and capacity building in small states. *Oxford Review of Education, 27*(3), pp. 395-409.

Dodani, S., & LaPorte, R. (2008). Ways to strengthen research capacity in developing countries: Effectiveness of a research training workshop in pakistan. *Journal of the Royal Institute of Public Health, 112*, 578-587.

Gapp, R., & Fisher, R. (2006). Achieving excellence through innovative approaches to student involvement in course evaluation within the tertiary education sector. *Quality Assurance in Education, 14*(2), 156.

Habte, A. (1991). Educational development: The challenge for bridging the gap
. In A. Boeren, & K. Epskamp (Eds.), *Education, culture and productive life* (). The Hauge: CESO.

Hesse-Bieber, S. N., & Leavy, P. (2011). *The practice of qualitative research*. California: SAGE Publications Inc.

Lansang, M. A., & Dennis, R. (2004). Building capacity in health research in the developing world. *Bulletin of the World Health Organization, 82*(10) doi:10.1590/S0042-96862004001000012

Lightman, A., & Sadler, P. (1993). Teacher predictions versus actual student gains. *Physics Teacher, 31*(3), 162-67.

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks: SAGE Publications.

Pulliainen, A. T., Enninga, J., Fernandez-Arenas, E., & Griffiths, G. (2007). A course with a difference. *EMBO Reports, 8*(2), 117-120.

Rosei, F., Vayssieres, L., & Mensah, P. (2008). Materials science in the developing world: Challenges and perspectives for africa. *Advanced Materials, 20*(24), 4627-4640.

Thorsteinsdottir, H., Ray, M., Kapoor, A., & Daar, A. S. (2011). Health biotechnology innovation on a global stage. *Nat Rev Micro, 9*(2), 137-143.

Wagner, C. S., Brahmakulam, I., Jackson, B., Wong, A., & Yoda, T. (2001). *Science and technology collaboration: Building capacity in developing countries?*. Santa Monica: Rand Publications.

Wang, G. G., & Wilcox, D. (2006). Training evaluation: Knowing more than is practiced. *Advances in Developing Human Resources, 8*(4), 528.

Appendix A

Tables

Table 1. 2011 Questionnaire Participants Demographic Information

		Frequency (N=22) (%)
Participants' Highest Level of Completed Education	Undergraduate	4 (18.2)
	Masters	12 (54.5)
	PhD	3 (13.6)
	Other	3 (13.6)
Participants' Current Employment Status	Prof[*]	14 (63.6)
	Prof* & Res[±]	3 (13.6)
	Prof[*], Res[±], Health[§] Gov[α]	3 (13.6)
	Prof[*], Res[±], Gov[α] & Agr[≠]	1 (4.5)
	Prof[*], Res[±] & Health[§]	1 (4.5)

[*]Professor/Teacher
[±] Research Occupation
[§] Health Occupation
[α] Governmental Occupation
[≠] Agricultural Occupation

Table 2. Do 2011 Participants Have Plans to Use MbS, MbT, BinfS and BinfT?

	Yes # (%)	No # (%)
Plan to use MbS	22 (100)	0 (0.0)
Plan to use MbT	22 (100)	0 (0.0)
Plan to use BinfS	22 (100)	0 (0.0)
Plan to use BinfT	21 (95.5)	1 (4.5)

N = 22

Table 3. How Often 2011 Participants Plan to Use MbS, MbT, BinfS and BinfT

	Always # (%)	Often # (%)	Sometimes # (%)	Rarely # (%)	Never # (%)	Not Applicable # (%)
How often do you plan to use MbS	8 (36.4)	9 (40.9)	5 (22.7)	0 (0.0)	0 (0.0)	0 (0.0)
How often do you plan to use MbT	12 (54.5)	8 (36.4)	2 (9.1)	0 (0.0)	0 (0.0)	0 (0.0)
How often do you plan to use BinfS	9 (40.9)	7 (31.8)	6 (27.3)	0 (0.0)	0 (0.0)	0 (0.0)
How often do you plan to use BinfT	10 (45.5)	8 (36.4)	3 (13.6)	1 (4.5)	0 (0.0)	0 (0.0)

Table 4. 2010 Questionnaire Participants' Demographic Information

		Frequency (N=22) (%)
What Institution is Participant Associated With?	UofG	1 (25.0)
	A.H.R.I.	2 (50.0)
	No Response	1 (25.0)
Participants' Highest Level of Completed Education	Undergraduate	2 (50.0)
	Masters and Other	1 (25.0)
	PhD	1 (25.0)
Participants' Current Employment Status	Prof[*]	1 (25.0)
	Prof* & Other	1 (25.0)
	Res[±]	1 (25.0)
	Res[±] & Other	1 (25.0)

[*]Professor/Teacher
[±] Research Occupation

Table 5. Do 2010 Participants Have Plans to Use MbS, MbT, BinfS and BinfT?

	Yes # (%)	No # (%)
Plan to use MbS	4 (100.0)	0 (0.0)
Plan to use MbT	4 (100.0)	0 (0.0)
Plan to use BinfS	3 (75.0)	1 (25.0)
Plan to use BinfT	3 (75.0)	1 (25.0)

N = 4

Table 6. How Often 2010 Participants Use MbS, MbT, BinfS and BinfT?

	Always # (%)	Often # (%)	Sometimes # (%)	Rarely # (%)	Never # (%)	Not Applicable # (%)
How often do you use MbS	1 (25.0)	1 (25.0)	0 (0.0)	0 (0.0)	1 (25.0)	1 (25.0)
How often do you use MbT	2 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (25.0)	1 (25.0)
How often do you use BinfS	0 (0.0)	0 (0.0)	1 (25.0)	0 (0.0)	3 (75.0)	0 (0.0)
How often do you use BinfT	0 (0.0)	0 (0.0)	3 (75.0)	0 (0.0)	1 (25.0)	0 (0.0)

Table 7. Percentage of Participants Who would Recommend this Course to a Peer or Colleague

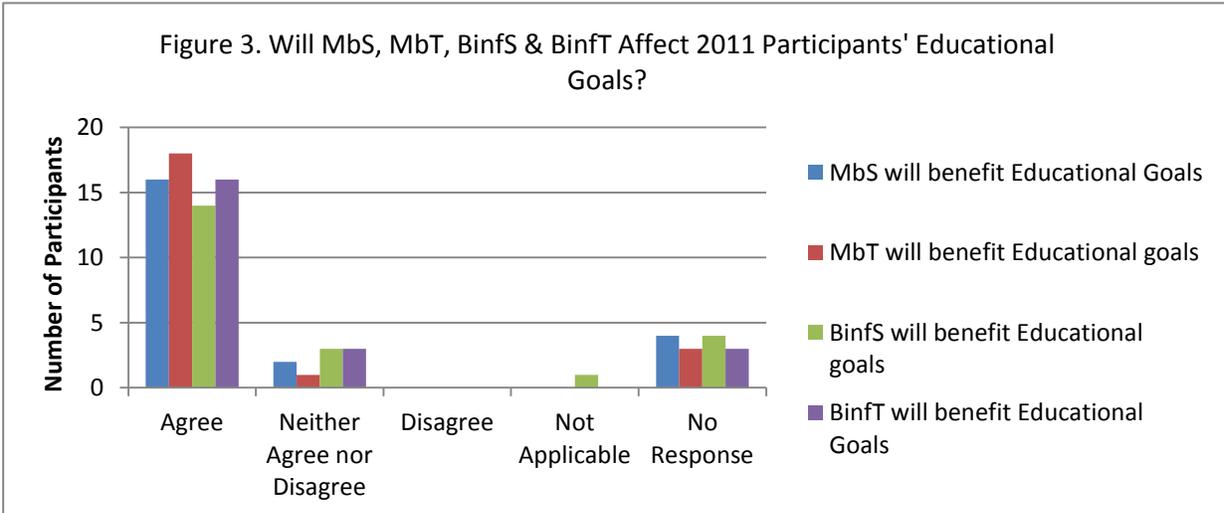| Year Participants Took Course	Percentage of Participants Who Would Recommend Course (%)
2009	100
2010 (Surveyed in 2010)	100
2010 (Surveyed in 2011)	100
2011	100

Appendix B

Figures

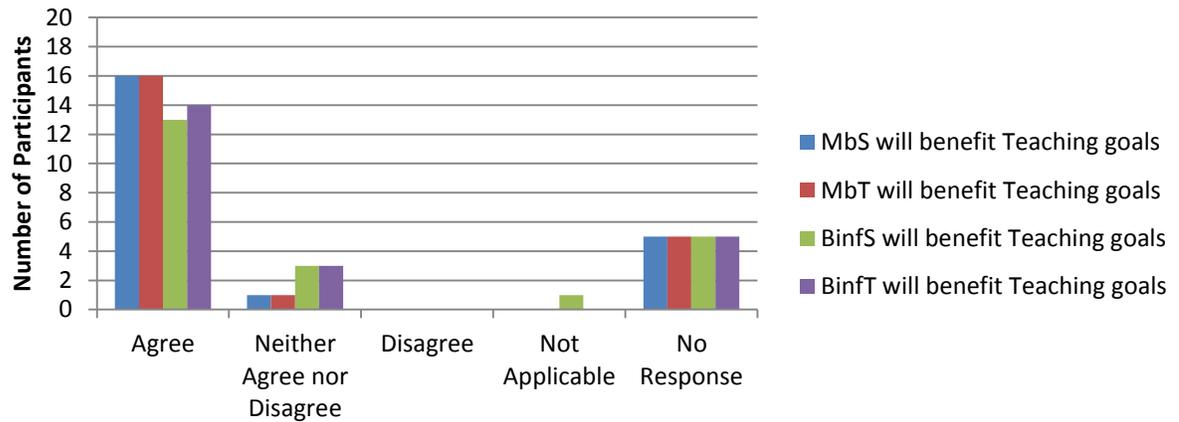Figure 1. Will MbS, MbT, BinfS & BinfT Affect 2011 Participants' Work Goals?

- MbS will benefit Work goals
- MbT will benefit Work goals
- BinfS will benefit Work goals
- BinfT will benefit Work goals

Figure 2. Will MbS, MbT, BinfS & BinfT Affect 2011 Participants' Research Goals?

- MbS will benefit Research goals
- MbT will benefit Research goals
- BinfS will benefit Research goals
- BinfT will benefit Research goals

Figure 3. Will MbS, MbT, BinfS & BinfT Affect 2011 Participants' Educational Goals?

- MbS will benefit Educational Goals
- MbT will benefit Educational goals
- BinfS will benefit Educational goals
- BinfT will benefit Educational Goals

Figure 4. Will MbS, MbT, BinfS & BinfT Affect 2011 Participants' Teaching Goals?

Figure 5. 2011 Participants' Cofidence in Teaching MbS, MbT, BinfS & BinfT
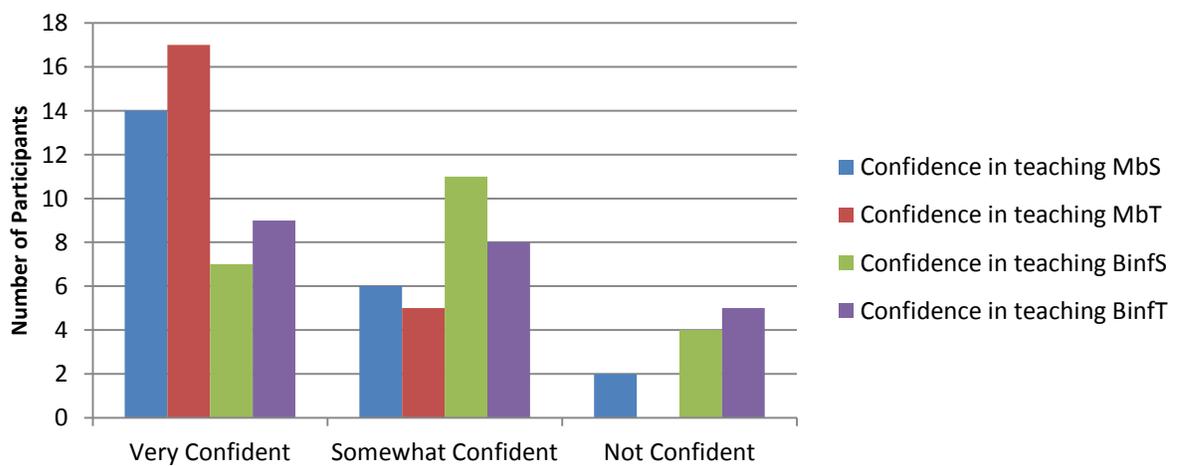
Figure 6. 2011 Participants' Perceptions of What Affects the Application of What They Learn - Before the Course
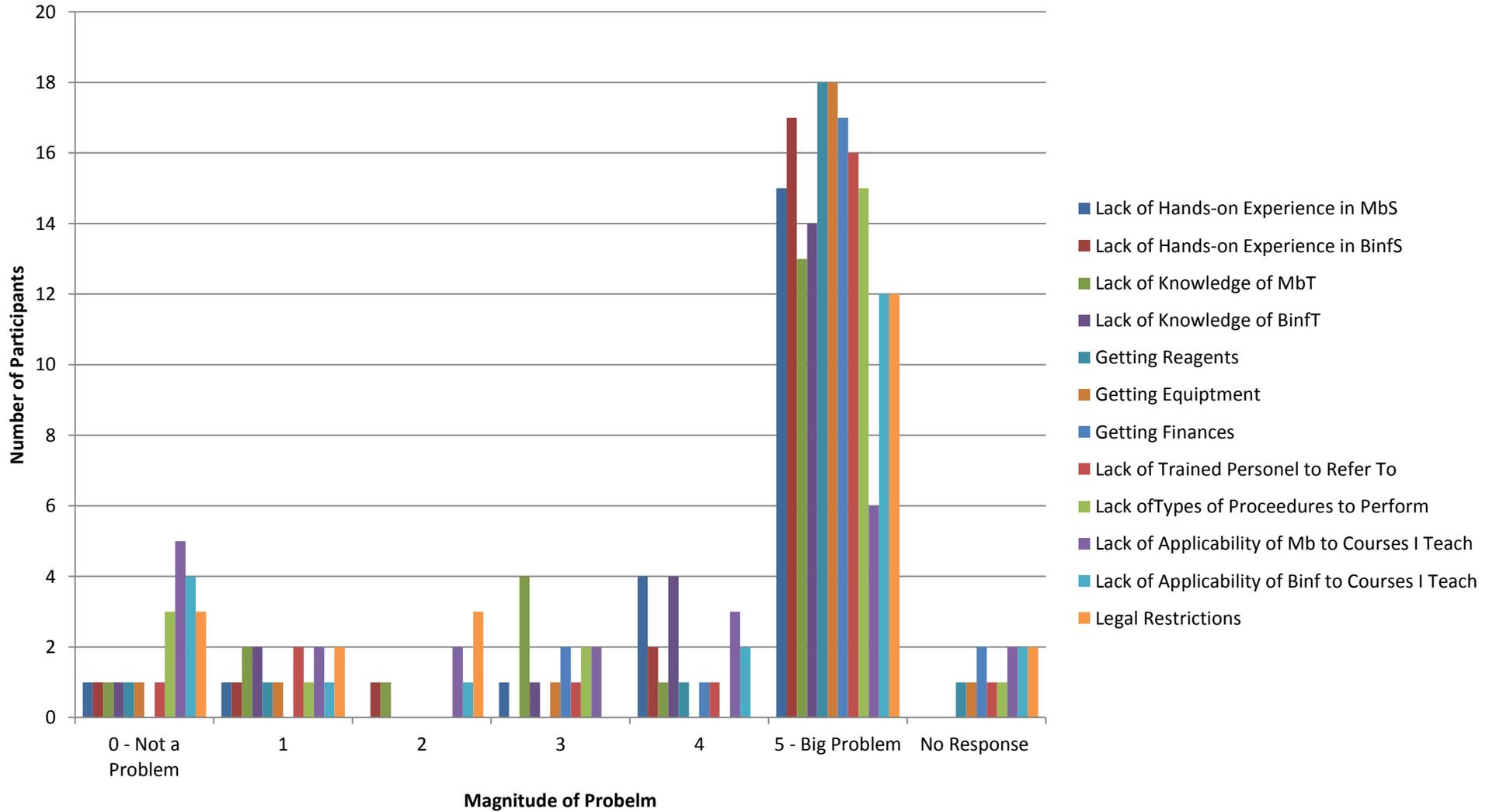
Figure 7. 2011 Participants' Perceptions of What Affects the Application of What They Learn - <u>After</u> the Course
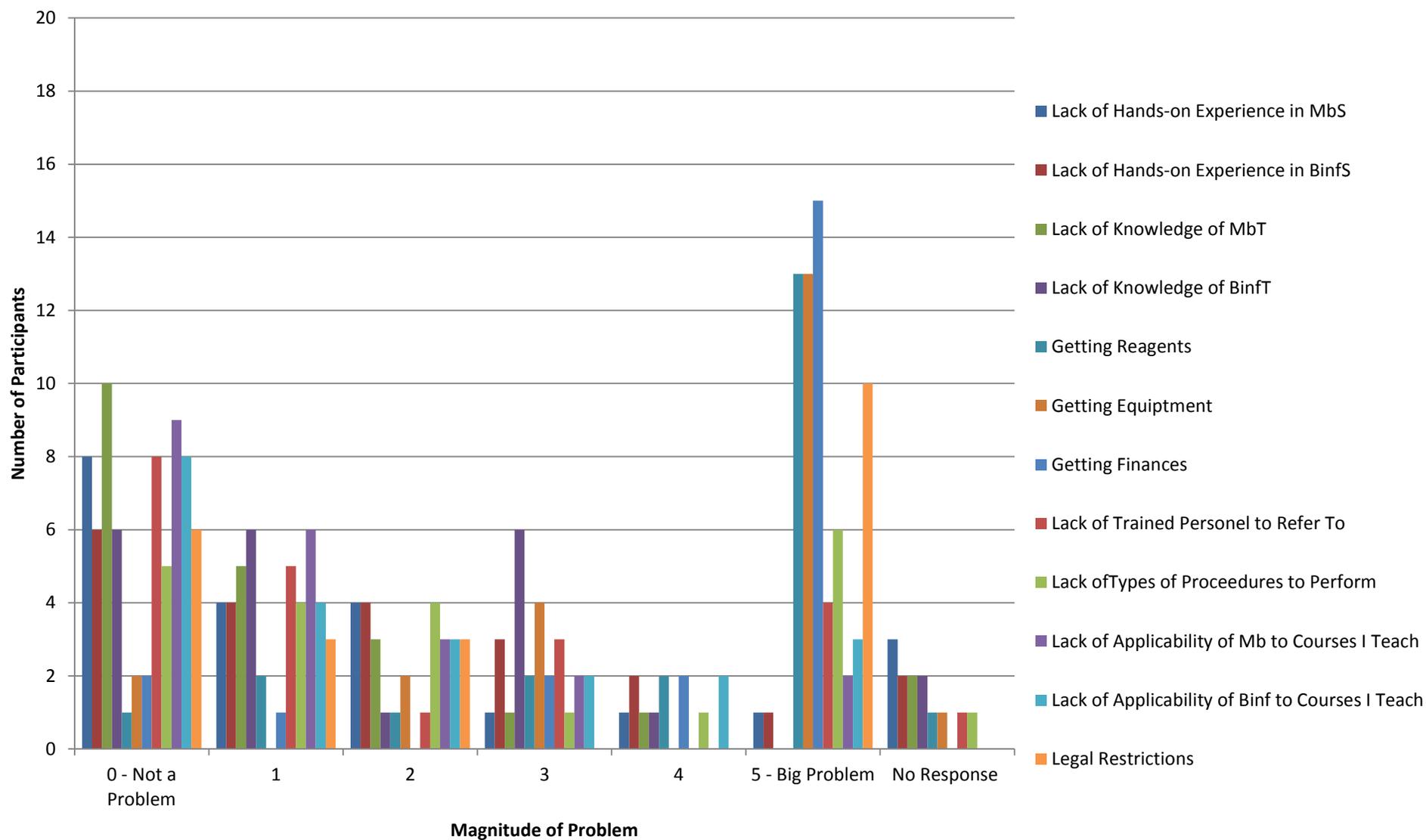
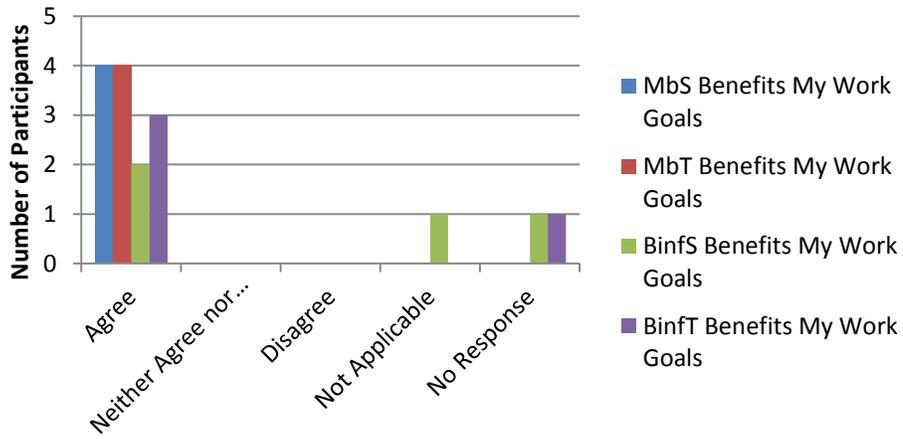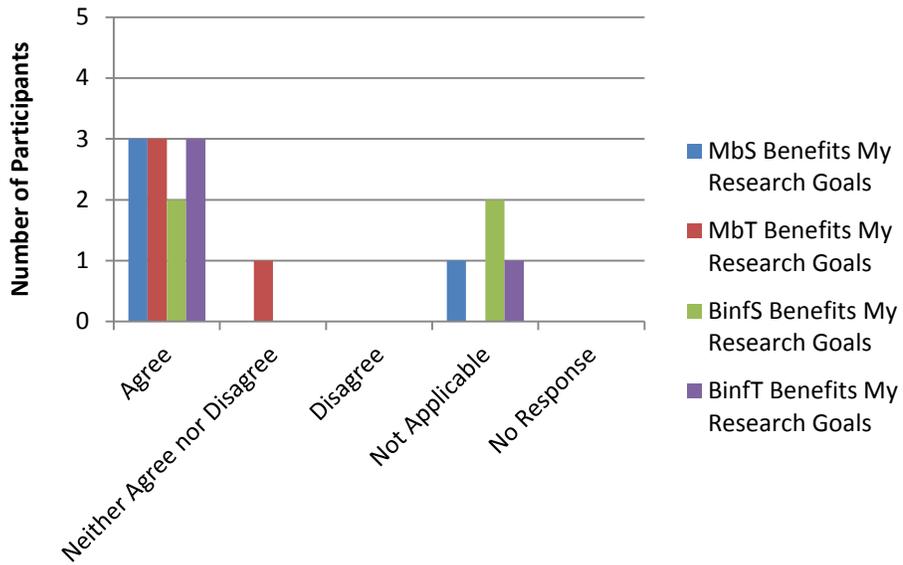**Figure 8. Does MbS, MbT, BinfS & BinfT Affect 2010 Participants' Work Goals?**

Legend:
- ■ MbS Benefits My Work Goals
- ■ MbT Benefits My Work Goals
- ■ BinfS Benefits My Work Goals
- ■ BinfT Benefits My Work Goals

Y-axis: Number of Participants (0 to 5)
X-axis: Agree, Neither Agree nor ..., Disagree, Not Applicable, No Response

Figure 9. Does MbS, MbT, BinfS & BinfT Affect 2010 Participants' Research Goals?

Legend:
- ■ MbS Benefits My Research Goals
- ■ MbT Benefits My Research Goals
- ■ BinfS Benefits My Research Goals
- ■ BinfT Benefits My Research Goals

Y-axis: Number of Participants (0 to 5)
X-axis: Agree, Neither Agree nor Disagree, Disagree, Not Applicable, No Response

Figure 10. Does MbS, MbT, BinfS & BinfT Affect 2010 Participants' Educational Goals?

Legend:
- ■ MbS Benefits My Educational Goals
- ■ MbT Benefits My Educational Goals
- ■ BinfS Benefits My Educational Goals
- ■ BinfT Benefits My Educational Goals

Y-axis: Number of Participants (0 to 5)
X-axis: Agree, Neither Agree nor Disagree, Disagree, Not Applicable, No Response
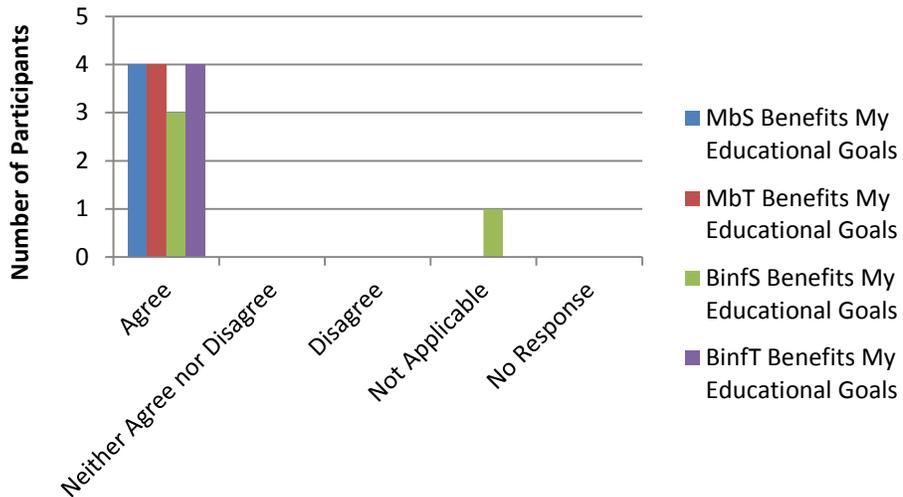
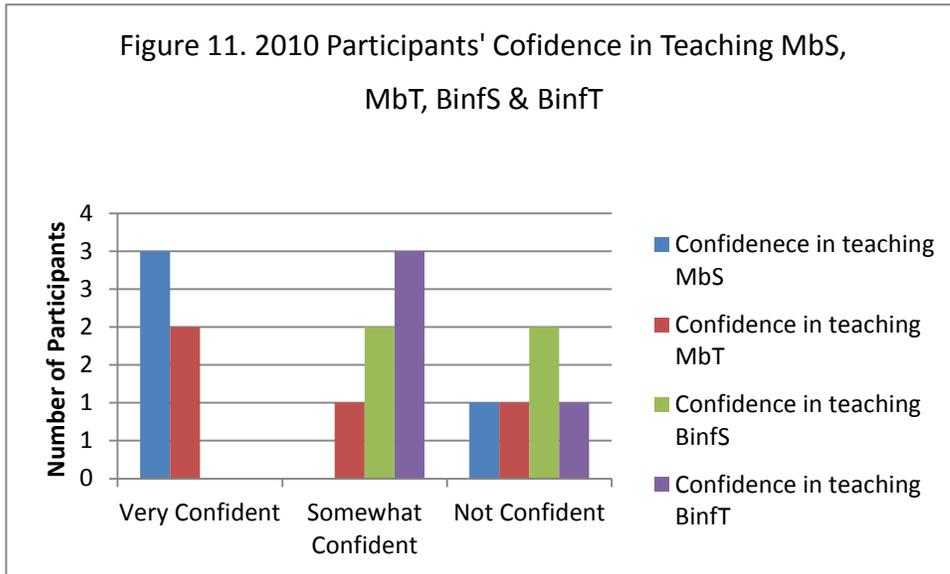Figure 11. 2010 Participants' Cofidence in Teaching MbS, MbT, BinfS & BinfT

Figure 12. What Factors Affect 2010 Participants' Decisions to Use MbS?
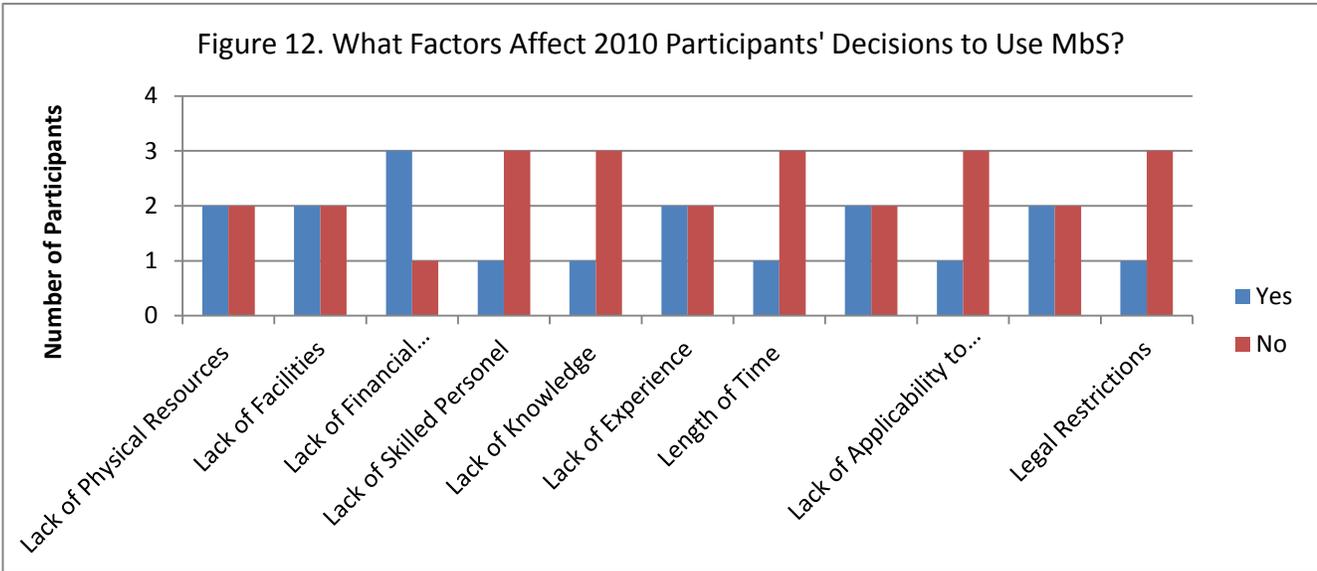

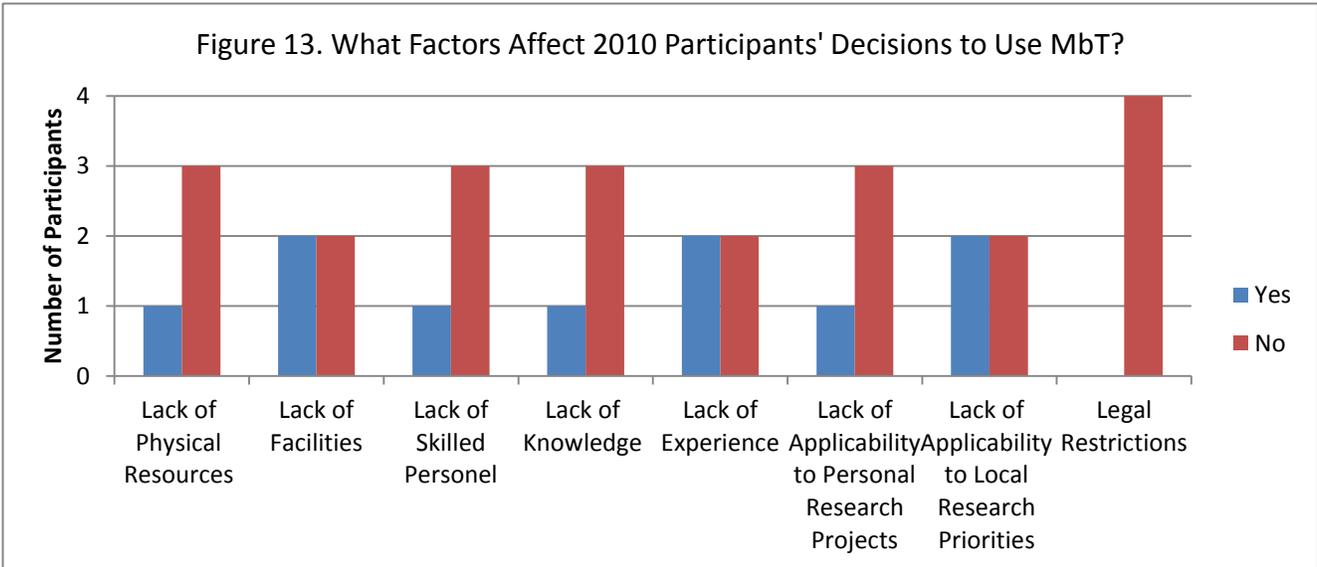Figure 13. What Factors Affect 2010 Participants' Decisions to Use MbT?

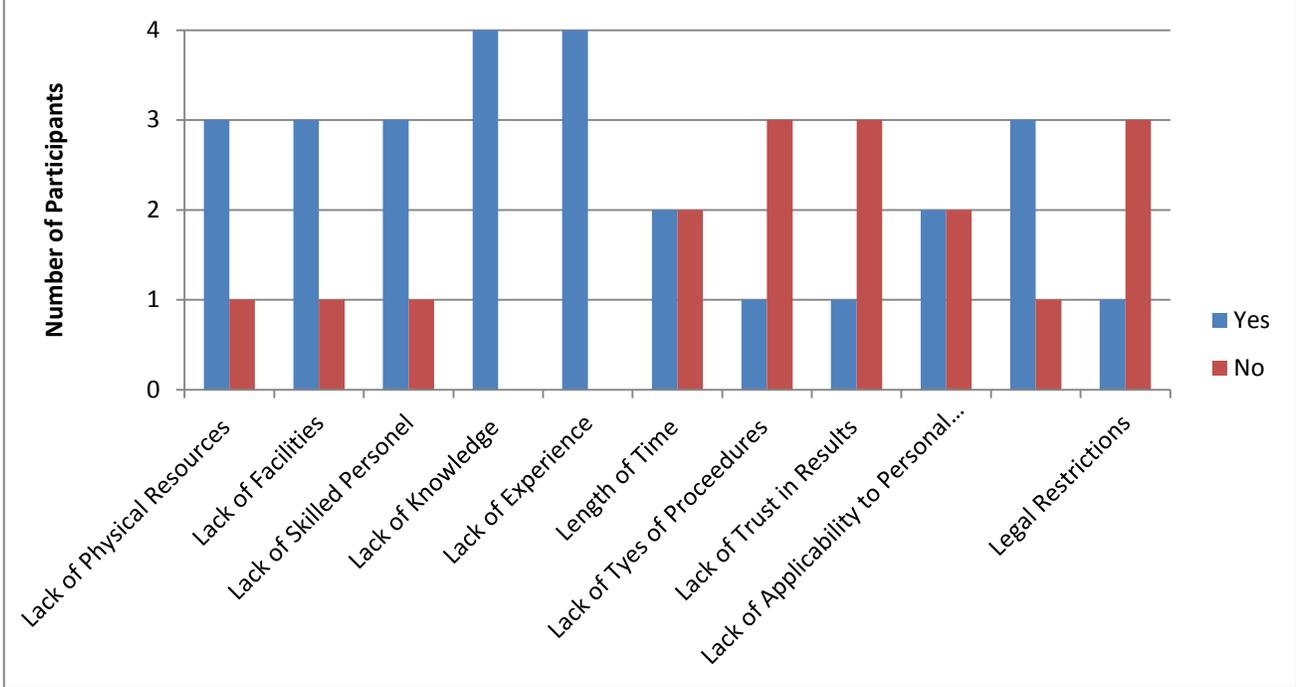Figure 14. What Factors Affect 2010 Participants' Decisions to Use BinfS?

Figure 15. What Factors Affect 2010 Participants' Decisions to Use BinfT?
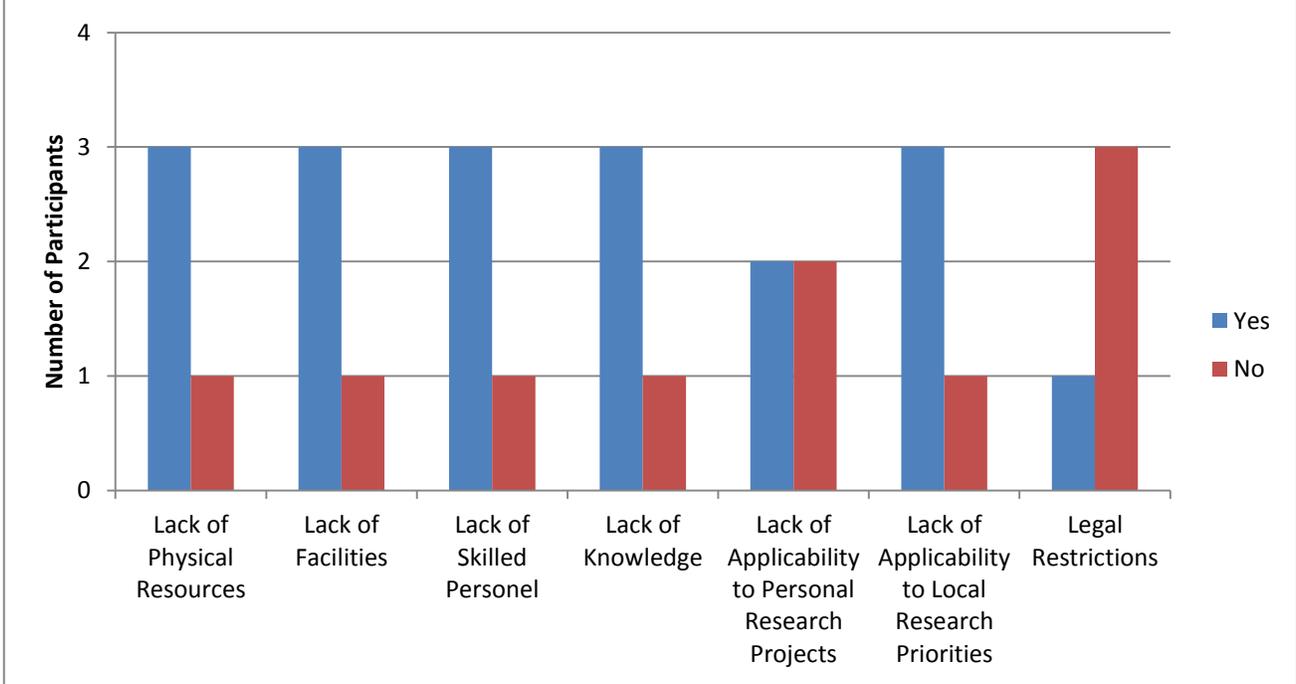
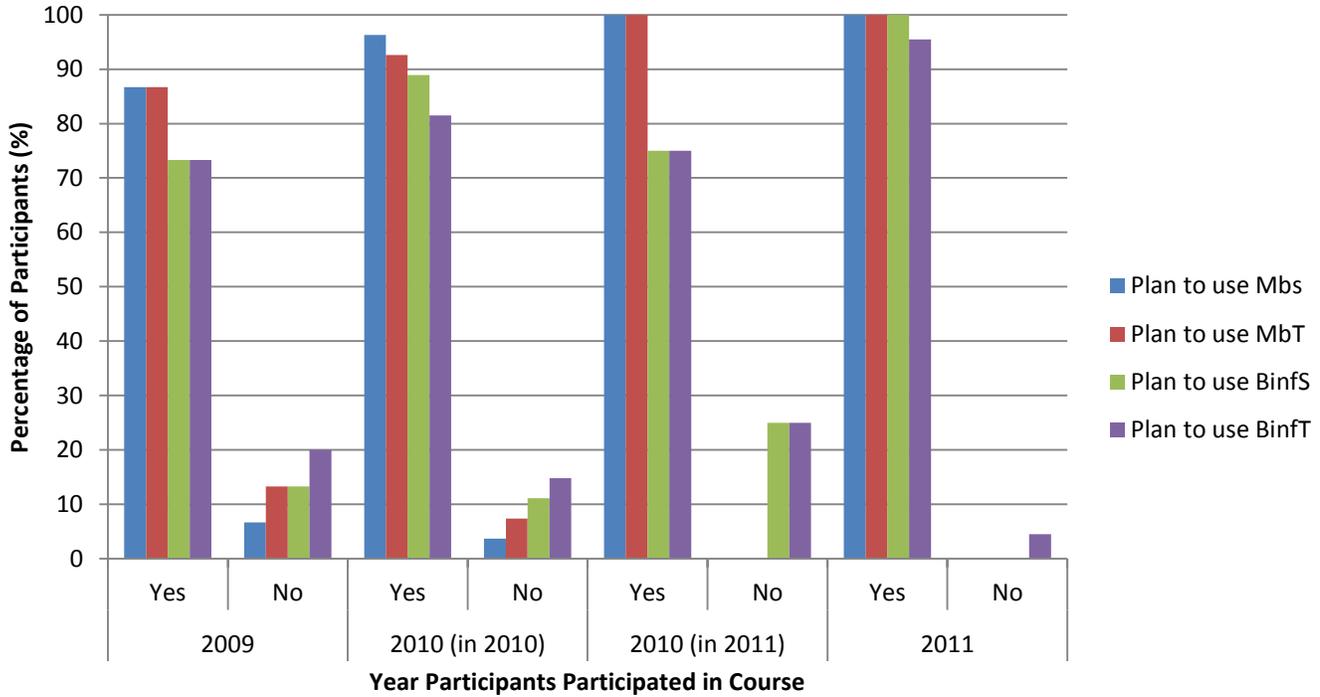Figure 16. Participants' Anticipated Use of MbS, MbT, BinfS and BinfT

Figure 17. Participants' Actual Use of MbS, MbT, BinfS and BinfT