Evaluation Report

Research Experiences for Undergraduates and Veterinary Students

June 7-July 30, 2010

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Executive Summary

Brief Synopsis of Event

The NIMBioS *Research Experiences for Undergraduates* (REU) and *Research Experiences for Veterinary Students* (REV) programs took place simultaneously on the University of Tennessee, Knoxville (UT) campus June 7-July 30, 2010. Thirteen undergraduates, three veterinary students and two high school teachers from 15 different institutions across the United States were chosen to participate. During the eight-week long program, participants lived on campus, and worked in teams with UT faculty to conduct research at the interface of mathematics and biology. The award included a stipend, housing and some funding to support travel. Research topics for the 2010 program were modeling the effects of climate change on ant foraging behavior in the Great Smoky Mountains National Park; predicting the park's biodiversity; modeling Johne's disease in cattle; modeling the growth and development of plant pathogens; and modeling the dynamics of cat populations in the community. Mentors in the program included UT professors Suzanne Lenhart (Professor in Applied Mathematics, Associate Director of NIMBioS), Shigetoshi Eda (Center for Wildlife Health, Department of Forestry, Wildlife and Fisheries), Paul Armsworth (Assistant Professor, Department of Ecology and Evolutionary Biology), Steven Wise, (Assistant Professor, Department of Mathematics), Kim Gwinn (Associate Professor, Entomology and Plant Pathology), and John New (Professor, Department Head, Comparative Medicine). NIMBioS postdoctoral fellows William Godsoe, and Sharon Bewick also served as mentors (See Appendix A).

Evaluation Design

A pre/post evaluation design was used to measure participant changes in participant research skills and knowledge as a result of taking part in the program, as well as participant satisfaction. Electronic surveys aligned to the following evaluation questions were designed by the NIMBioS Evaluation Coordinator with input from the NIMBioS Associate Director for Education, Outreach, and Diversity, and the Education and Outreach Coordinator.

1. Were participants satisfied with the program overall?
2. Did the research experience meet participant expectations?
3. Did the research experience impact participant plans to go to graduate school?
4. To what extent did participants increase their research skills during the program?
5. To what extent do participants feel they gained knowledge about the research process?
6. How satisfied were participants with their mentors?
7. How satisfied were participants with the accommodations offered by NIMBioS?
8. What changes do participants feel NIMBioS should make in the program for next year?

The final instruments were hosted online via the University of Tennessee's online survey host mrInterview. Links to the pre-survey were emailed to the 18 REU/REV participants on June 1, 2010. A reminder email was sent to non-responding participants on June 4, 2010. By June 7, 2010, 18 participants had given their feedback, for a response rate of 100%.

Links to the post-survey were sent to the 18 REU/REV participants on August 3, 2010. Reminder emails were sent to non-responding participants on August 18 and 24, 2010. By September 1, 2010, 18 participants had given their feedback, for a response rate of 100%.

An electronic demographic survey aligned to the reporting requirements of the National Science Foundation was designed by the NIMBioS Evaluation Coordinator with input from the NIMBioS Director. The final instrument was hosted online via the University of Tennessee's online survey host mrInterview. Links to the survey were sent to the 18 program participants on May 10, 2010. Reminder emails were sent to non-responding participants on May 20 and 23, 2010. By May 25, 2010, 18 participants had filled out the survey for a response rate of 100%. Demographic questions regarding gender, race, and ethnicity, and disability status were optional (disability status is not reported in this evaluation report). All demographic information is confidential, and results are reported only in the aggregate. When feasible, the evaluator filled in missing demographic data from other sources (e.g. address, institution, field of study). The evaluator did not assume race, ethnicity, or disability status for any participant who did not report this information.

Highlights of Results

- Overall satisfaction with the program was high among participants, 94% of whom said they were “satisfied” or “very satisfied” with their experiences and would recommend the program to others.

- Fifteen of the eighteen participants said most or all of their expectations were met or exceeded during the program, while three participants said only “some” of their expectations were met.

- The majority of participants (89%) thought the overall workload during the program was “just about right,” while 11% thought either “too much” or “too little” work was assigned.

- Overall, participants were highly satisfied with their mentors, indicating that they were very helpful and supportive during the research experience. Participants rated their mentors highly, with the average mentor rating at 1.71 (on a scale of -2 to 2, with 2 being the most favorable).

- Participants rated the usefulness of the BCMB information sessions highly as well. Ratings ranged from an average of 0.11 for the “Diversity in Science” session, to an average of 0.44 for the “Speaking to a Professional Audience” session (on a scale of -1=not useful to 1=very useful).

- Gains in several research-related skills were reported by participants, with an average rating for all skills of 0.75 on the pre-survey and 1.07 on the post-survey (on a 5-point Likert scale from -2=extremely poor at the skill to 2=excellent at the skill).

- Participants reported gains in knowledge regarding several research-related topics. Before the program, participants on average rated themselves 0.55 on a 5-point Likert scale from -2=extremely poor understanding to 2=excellent understanding of the topics. After participation, the average rating was 1.28.

- Sixty-seven percent of participants said that participating in the program impacted their plans to go to graduate school in some way. Some participants said that the experience reinforced their previous decisions to attend graduate school, while others said that the experience made them more interested in integrating math and biology into their graduate school plans.

Conclusions and Recommendations

According to participant data, the REU/REV program was successful. Overall satisfaction with the program was high, with 94% of participants being "satisfied" or "very satisfied" with their experiences. Seventeen of the 18 participants also indicated they would recommend the program to others. The majority of participants said the program met or exceeded their expectations, and that the workload was appropriate for the program. Participants were also highly satisfied with their mentors, indicating that they were skillful, helpful, and positively impacted the research experience overall.

Participants showed high levels of satisfaction with the accommodations offered during the program, with the majority being highly satisfied with computing resources, extracurricular activities, housing, and mail service. Several participants suggested providing a gym pass to the student recreation center for participants in the future.

Several information sessions organized in conjunction with UT's Department of Biochemistry and Cellular and Molecular Biology (BCMB) were rated highly by participants. Participants were asked to rate the usefulness of these sessions on a scale of -1=not useful to 1=very useful. Ratings for the sessions ranged from an average of 0.11 for the "Diversity in Science" session, to an average of 0.44 for the "Speaking to a Professional Audience" session.

Participants showed increased levels of confidence regarding how well they felt they could carry out several research-related skills. Analysis of pre and post responses showed that gains were reported in every skill on the survey, with an average rating for all skills at 0.75 on the pre-survey and 1.07 on the post-survey (on a 5-point Likert scale from -2 to 2 for extremely poor at the skill to excellent at the skill). Participants showed the greatest skill gains in designing research plans, using mathematical tools or models to describe a biological scenario, and using research literature.

Participants also showed increased levels of knowledge about the research process. Before the program, participants on average rated themselves 0.55 on a 5-point Likert scale from -2 to 2 for extremely poor understanding of the topic to excellent understanding. After participation, the average rating was 1.28. Participants showed the greatest gains in understanding the nature of interdisciplinary research collaborations and the nature of the research process.

Sixty-seven percent of participants said that participating in the program impacted their plans to go to graduate school in some way. Three participants said that the experience reinforced their previous decisions to attend graduate school, while others said that the experience made them more interested in integrating math and biology into their graduate school plans. All 18 participants planned on attaining graduate degrees before participating in the program, while 17 planned on doing so after the program. Thirteen of the 15 participants who planned to obtain a Ph.D. before the program did not change their minds after participation; however, the remaining two decided to pursue a lesser degree after participating. One of three participants who planned to pursue a master's degree before the program kept his/her decision the same after participation; however, the other two indicated that participating in the program led them to want to pursue a Ph.D. instead of a master's degree.

Based on analysis of participant response data, the recommendations are as follows:

- The program appears to be on-track—no major changes to content or format are needed.
- Several participants felt the career panel did not apply to their career goals. Consider representing more diverse careers on the career panel—specifically those working in veterinary research and mathematics.
- For future implementations of the program, consider the feasibility of offering participants a pass to the student recreation center.

REU/REV Evaluation Report

Background

Introduction

The NIMBioS *Research Experiences for Undergraduates* (REU) and *Research Experiences for Veterinary Students* (REV) programs took place simultaneously on the University of Tennessee, Knoxville (UT) campus June 7-July 30, 2010. Thirteen undergraduates, three veterinary students and two high school teachers from 15 different institutions across the United States were chosen to participate in the program.

During the eight-week long program, participants lived on campus at the University of Tennessee, Knoxville, (UT) and worked in teams with UT faculty to conduct research at the interface of mathematics and biology. The award included a stipend, housing and some funding to support travel.

Research topics for the 2010 program were modeling the effects of climate change on ant foraging behavior in the Great Smoky Mountains National Park; predicting the park's biodiversity; modeling Johne's disease in cattle; modeling the growth and development of plant pathogens; and modeling the dynamics of cat populations in the community. Mentors in the program included UT professors Suzanne Lenhart (Professor in Applied Mathematics, Associate Director of NIMBioS), Shigetoshi Eda (Center for Wildlife Health, Department of Forestry, Wildlife and Fisheries), Paul Armsworth (Assistant Professor, Department of Ecology and Evolutionary Biology), Steven Wise, (Assistant Professor, Department of Mathematics), Kim Gwinn (Associate Professor, Entomology and Plant Pathology), and John New (Professor, Department Head, Comparative Medicine). NIMBioS postdoctoral fellows William Godsoe, and Sharon Bewick also served as mentors (See Appendix A).

Project Backgrounds

Participants were selected to work on one of five research projects. Descriptions of the projects have been provided by program mentors:

Plant Modeling (Gwinn, Joo)

Essential oils are highly volatile substances synthesized by most herbs and spices. The term essential oil refers not only to the complex oils isolated from the plant, but also to their constituent compounds. Essential oils are potential replacements for synthetic pesticides in sustainable or organic agriculture. The objective of this REU team was to develop models for the effects of plant-derived essential oils on growth and development of plant pathogens. Results of this study will contribute to the field of biological control of pathogens.

Johne's Disease (Lenhart, Eda)

This group built an epidemic model for Johne's disease for cattle on a farm. Progression through the stages of the disease was included. The group investigated the effects of specific test regimes and control procedures on the course of the disease. The group intended to also look at the revenue effects, including milk production and loss of cattle.

Biodiversity in the GSMNP (Armsworth, Godsoe)

One of the major challenges facing ecologists is the need to describe and predict biodiversity. In particular it is important for ecologists to understand: 1) how many different kinds of organisms occur at a given location, and 2) how the organisms change as we move from one location to another. Ecologists typically need to spend years collecting field data and identifying specimens before we can hope to address these problems. However NIMBioS has access to an exciting, but poorly explored database of biodiversity observations from one of the major biodiversity hotspots of North America, Great Smoky Mountains National Park (http://www.dlia.org/), which includes more than 100,000 individual observations. The goal of this group was to train REU students to develop a self contained project that models the causes or patterns of biodiversity in some of these observations. Though mentors expected the students would have a fair bit of latitude in developing the project, some likely avenues of research were modeling Beta diversity--the change in species composition from one location to another or one time to another, and modeling distributions of individual taxa or testing if patterns of biodiversity change as we move from one trophic level to another.

Ant foraging and Climate Change (Wise, Bewick)

This group investigated the foraging behavior of different ant species, and then used this information to predict shifts in ant species abundance that might occur as a result of climatic change. In particular, the group was interested in studying the impact of colony size and foraging strategy on foraging efficiency, food discovery rate, behavioral dominance and overwintering ability. The study involved both experimental and theoretical work and, ultimately, the goal was to gain a mechanistic understanding of the trade-offs (e.g. dominance-discovery, dominance-thermal tolerance) that allow for coexistence amongst ant species. Once the group identified some of the factors that allow different ant species to coexist, they began to examine how the interactions between these ant species were likely change as a result of climatic warming. This information will be used to develop models that predict whether specific ant species are likely to increase or decrease in abundance under warming regimes.

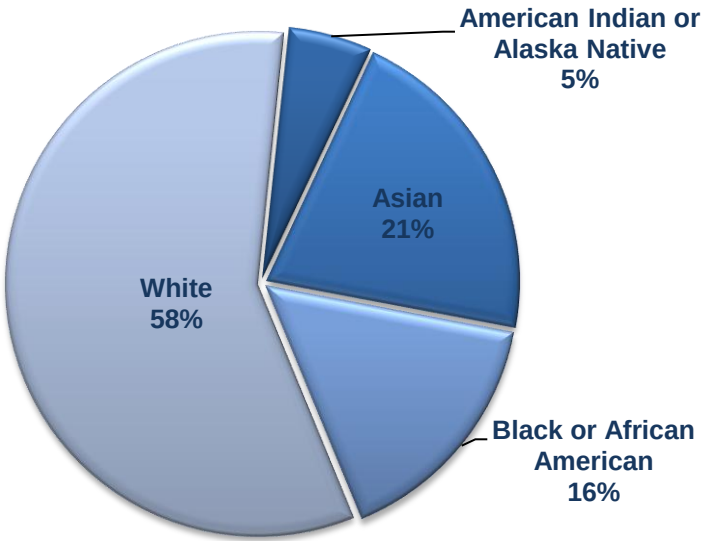
Dog and Cat Population Dynamics (Lenhart, New)

This group investigated a population model at the community level for cats and dogs. The group estimated the number of cats and dogs in the surrounding community and predicted future growth with a model that can be used in other communities. Considering the effects of spay and neuter strategies, appropriate timing and their potential impact on intake and euthanasia rates at animal shelters, the group sought to optimize such control strategies. The group expected to use data from the literature and from local sources.

Participant Demographics

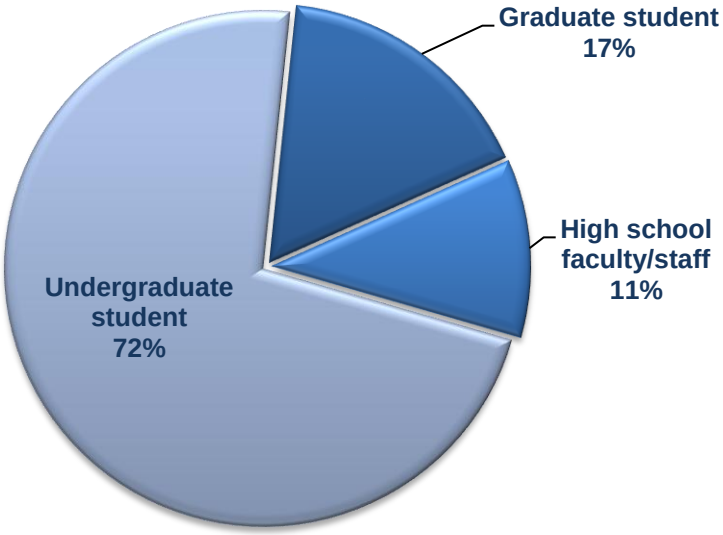
The 11 females and 7males (none of whom self-identified as Hispanic/Latino) came from a diverse array of racial backgrounds (Figure 1).

Figure 1. Racial composition of participants (n =18)



The majority of participants were undergraduate students, however graduate students and high school staff also participated (Figure 2).

Figure 2. Status of participants (n=18)



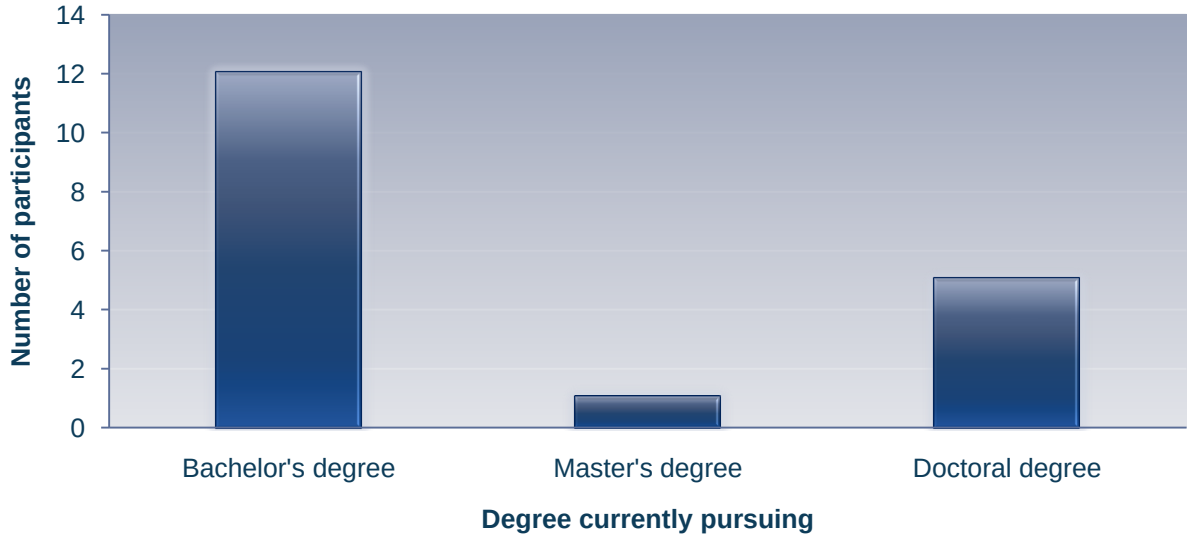
Primary fields of study for the 18 participants included biological/biomedical sciences, chemistry, computer science, health science, and mathematics (Table 1).

Table 1. Participant fields of study and areas of concentration

Field of Study	Concentration	# Participants
Biological/Biomedical Sciences	Biology/Biomedical Sciences, General	1
	Biometrics & Biostatistics	1
	Zoology	1
Chemistry	Analytical	1
Computer & Information Sciences	Computer Science	1
Health Sciences	Veterinary Medicine	3
Mathematics	Applied Mathematics	1
	Math/Statistics, General	4
	Mathematical Biology	3
	Mathematics, General	1
	Operations Research	1

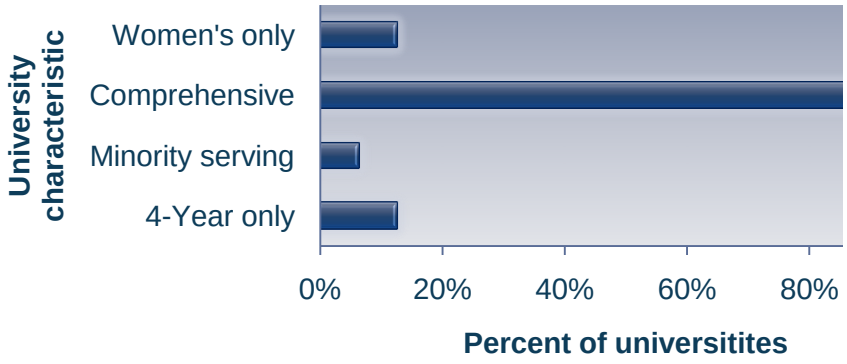
Within these fields of study, participants indicated they were currently pursuing a bachelor's, master's, or doctoral degree (Figure 3).

Figure 3. Degrees currently pursued by participants



Participants represented 15 unique institutions across the United States. Within the U.S., 11 different states were represented. Included in the institutions were 13 universities and two high schools. Of the 13 colleges/universities, most were classified as comprehensive (having undergraduate and graduate programs) schools (Figure 4).

Figure 4. Characteristics of participants' universities



Evaluation Design

Evaluation Questions

The evaluation of the program was both formative and summative in nature, in that the data collected from participants was intended to both gain feedback from participants about the quality of the current program and also to inform next year's program. A pre/post evaluation design was used to measure self-reported changes in participant skills and knowledge as a result of taking part in the program.

The evaluation framework was guided by Kirkpatrick's Four Levels of Evaluation model for training and learning programs (Kirkpatrick, 1994[1]). Several questions constituted the foundation for the evaluation:

1. Were participants satisfied with the program overall?
2. Did the research experience meet participant expectations?
3. Did the research experience impact participant plans to go to graduate school?
4. To what extent did participants increase their research skills during the program?
5. To what extent do participants feel they gained knowledge about the research process?
6. How satisfied were participants with their mentors?
7. How satisfied were participants with the accommodations offered by NIMBioS?
8. What changes do participants feel NIMBioS should make in the program for next year?

Evaluation Procedures

Electronic surveys aligned to the evaluation questions were designed by the NIMBioS Evaluation Coordinator with input from the NIMBioS Associate Director for Education, Outreach,

[1] From Kirkpatrick, D.L. (1994). *Evaluating Training programs: The Four Levels.* San Francisco, CA: Berrett-Koehler.

and Diversity, and the Education and Outreach Coordinator. The final instruments were hosted online via the University of Tennessee's online survey host mrInterview.

Links to the pre-survey were emailed to the 18 REU/REV participants on June 1, 2010. A reminder email was sent to non-responding participants on June 4, 2010. By June 7, 2010, 18 participants had given their feedback, for a response rate of 100%.

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Data Analysis

Data from the electronic surveys included both forced-response and supply-item questions. All data were downloaded from the online survey host into the statistical software package SPSS for analysis. Quantitative data were analyzed using SPSS, while qualitative data were analyzed in SPSS Text Analysis for Surveys. Qualitative responses were categorized by question and analyzed for trends.

Evaluation Findings

Respondent Satisfaction

Overall Satisfaction

Overall satisfaction with the program was high among participants, 94% of whom said they were "satisfied" or "very satisfied" with their experiences (one participant indicated feeling "neutral" about his/her overall satisfaction). Some participant comments:

"I felt great about this research experience because I was never overwhelmed with work, I always had time to enjoy the summer with my fellow students, but on the other hand, I was part of a serious and professional research. I worked and learned and gained a lot by being in Kim Gwinn's research group while having a great time in Knoxville."

"This was such a great experience; one that really opened my eyes, in more ways than one. I am much more aware of the wonders of biology that I see every day and am SO much more interested in applying math to biological/ecological situations. I really appreciate the opportunity to have participated in such a program."

"Thank you, NIMBioS, for an awesome summer!"

Seventeen of the 18 participants said would recommend the program to others. The one participant who said he/she would not recommend the program said that he/she did not know anyone who would be interested in it.

Before beginning the REU/REV program, participants were asked what they hoped to gain through participation. More than half (55%) of the participants said they would like to gain understanding of how research is conducted:

"I hope to gain some research experience and some insights into the workings of mathematical modeling that will serve me well in my pursuit of my PhD. I also hope to network with professors and researchers at the top of the field of math ecology."

"I hope to gain some research experience in the field of biology and hopefully bioinformatics, too..."

"I hope to gain some experience in research in the field of statistics and biodiversity. I also look forward to working on and exploring interesting research topics that will possibly lead me to my honor thesis next year."

Other participants (6%) also said hoped to learn more about using mathematics in research:

"I hope to learn more math skills. I hope to gain confidence that I can use math not just in class but in "real life" situations. Also, I hope to have fun learning about non-mathematical aspects of the research, such as biology, and to reach amazing and useful

Participant comments about the overall experience:

"Excellent research experience! I am planning to continue the research to hopefully publish and present our results."

"I enjoyed the group, I think the program drew together people who all wanted to make the social side of things work and therefore it did."

"I love it. All the participants made it an enjoyable experience. I played soccer almost every week and we had 4 birthday parties. All are very great."

"I learned how a research process looks like and how to be creative to plan the research and come up with the method of research."

"…My favorite moments were when I was allowed to work outside of the classroom e.g. the visits to the dairy farm or writing the research paper. I think that this research project helped to clarify my interests in veterinary research and I appreciate more the mathematical aspect of biological research."

"This was such a great experience; one that really opened my eyes, in more ways than one. I am much more aware of the wonders of biology that I see every day and am SO much more interested in applying math to biological/ecological situations. I really appreciate the opportunity to have participated in such a program."

results that will be helpful in wider scope."

"Through participation in this program I hope to gain experience in the research and application of mathematics. I have taught for the past four years and I am now interested in learning new ways to apply math outside the classroom, particularly to other disciplines."

Other expectations for the program were gaining knowledge of interdisciplinary research in specific areas, and learning about careers at the interface of mathematics and biology:

"I would like to gain knowledge on a veterinarian's role in Science and Research. I would also like to gain more knowledge about the diseases we would be studying as a whole."

"I am hoping to get a feel for what it would take to make a career out of doing biomathematics research and modeling."

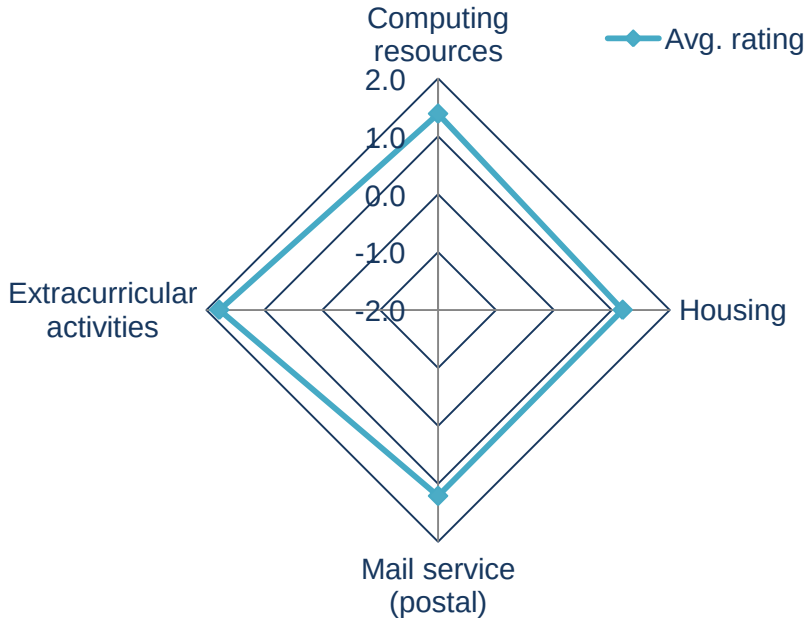
"I'm very interested in veterinary epidemiology, so I hope to gain a better perspective of what a career in that field would entail."

Fifteen of the eighteen participants said most or all of their expectations were met or exceeded during the program, while three participants said only "some" of their expectations were met. The majority of participants (89%) thought the overall workload during the program was "just about right," while 11% thought either "too much" or "too little" work was assigned.

Satisfaction with Accommodations

Overall, participants reported being satisfied with the computing, housing, mail, and extracurricular accommodations provided by NIMBioS during the program (Figure 5, answered on a 5-point Likert scale from -2 to 2 for "very dissatisfied" to "very satisfied").

Figure 5. Participant satisfaction with accommodations



While participants were satisfied overall with the accommodations, several suggestions were offered, including having a gym pass for the student recreation center and loaner laptops for

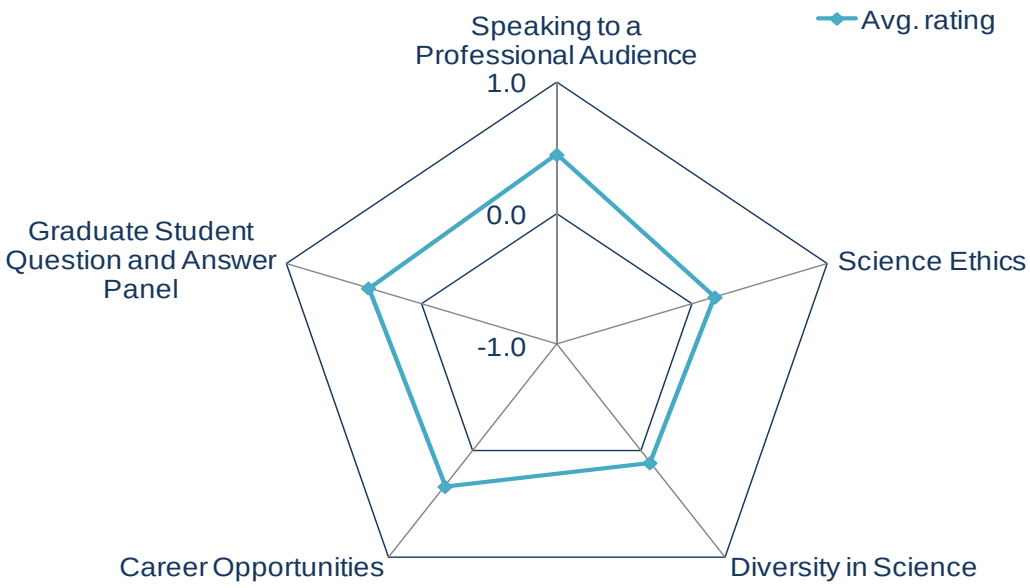
participants. Other suggestions were inclusion of a meal plan and more trips to the Great Smoky Mountains National park.

Satisfaction with BCMB Sessions

REU and REV participants were offered the opportunity to attend several sessions on topics relevant to graduate school and having a career in a science. Several of these sessions were organized in conjunction with UT's Department of Biochemistry and Cellular and Molecular Biology (BCMB). Participants were asked to rate the usefulness of these jointly sponsored sessions on a scale of -1=not useful to 1=very useful. Ratings for the sessions ranged from an average of 0.11 for the "Diversity in Science" session, to an average of 0.44 for the "Speaking to a Professional Audience" session (Figure 6).

> *"I found all of these sessions worth attending and all the speakers were well selected and well prepared and very helpful. I think it was a great thing for all of us, students, to get the chance to just attend all these well organized and well planned events."*

Figure 6. Ratings for co-sponsored BCMB sessions



While most undergraduates found the "Career Opportunities panel useful, some veterinary students felt it was not geared toward them:

> *"Several of the undergrads told me that they found "Career Opportunities" and the "Graduate Student Question and Answer Panel" sessions to be very helpful for them. However, since I'm already in veterinary school these two programs didn't really apply to me."*

"[The career and graduate student panels were] useful, but seemed more geared to younger participants, not those of us already in graduate school."

Another felt that the "Career Opportunities" panel was too focused on laboratory careers:

"The "Career Opportunities" panel was not very useful because it seemed the majority were from the lab. As a mathematician, I highly doubt I will be doing a career in the lab doing chemistry research. There was not a good diversity of mathematics or industry workers."

When asked which other sessions participants found useful, the overwhelming response was the mathematical modeling lectures offered by Dr. Lenhart:

"I learned a lot from Dr. Lenhart's Modeling Lectures."

"I really enjoyed the mathematical modeling lectures that Suzanne gave throughout the summer, as well as watching the math REU presentations at the end of the summer."

"Modeling lessons captured all main points of modeling and was a great way to go over things we learned in class."

Other sessions mentioned as useful were lectures on how to use new software, and Dr. Eda's talk on Johne's disease.

Satisfaction with Mentors

Each participant had two mentors during the program. Overall, participants were highly satisfied with their mentors, indicating that they were very helpful and supportive during the research experience. Some participant comments:

"Both Dr. Lenhart and Dr. Eda were incredibly helpful, and always went out of their way to make sure that any questions I had were answered quickly and correctly. They are extremely professional, and it would be a shame if someone did not recognize the skills and experience they had to offer for us."

"Dr. Joo was very straight to the point, told me what I did well and what I did not. This matches well with my working style. Dr. Gwinn is really awesome. I have not met such an encouraging and understanding professor before. She is someone who I definitely want to work with if I studied her field. I really enjoyed working with her."

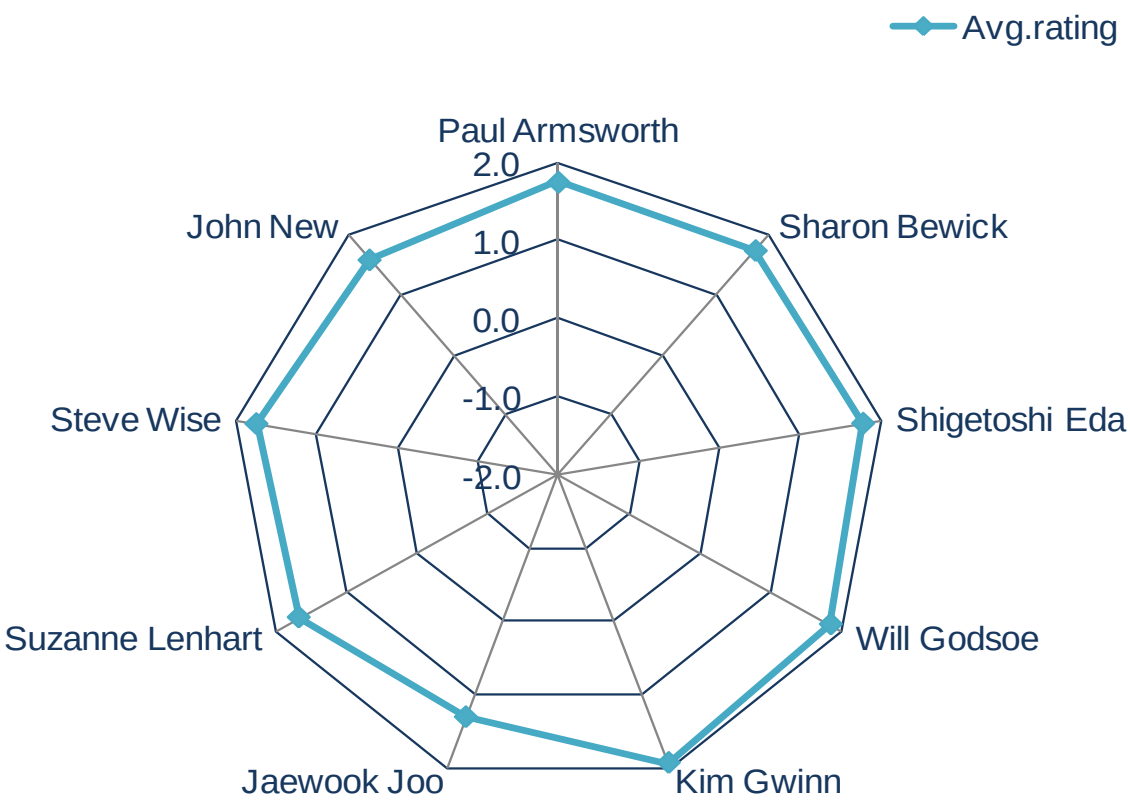
"Will and Paul were amazing! They were very supportive in everything that we did. They were great at giving us enough information to get us going and then being a little more hands-off until we requested help. I think that they really helped us to grow as independent researchers while also keeping things structured."

"Dr. New and Dr. Lenhart were excellent mentors for our research. I especially appreciated being able to talk to them about my own research interests. They gave great advice about further degrees and career opportunities. Dr. New and Dr. Lenhart both went out of their way to make us feel welcome and comfortable in Knoxville. They encouraged us to get out and experience everything that the city had to offer."

Participants were asked to rate their mentors on several desirable characteristics. Overall, participants rated their mentors highly, with the average mentor rating at 1.71 (on a scale of -2 to 2, with 2 being the most favorable). Participants rated several characteristics very highly, including offering constructive ideas for improvement, and positively impacting the research experience of participants (Figure 7 & Figure 8).

Figure 7. Average rating by mentor characteristic

Figure 8. Average mentor rating for all characteristics

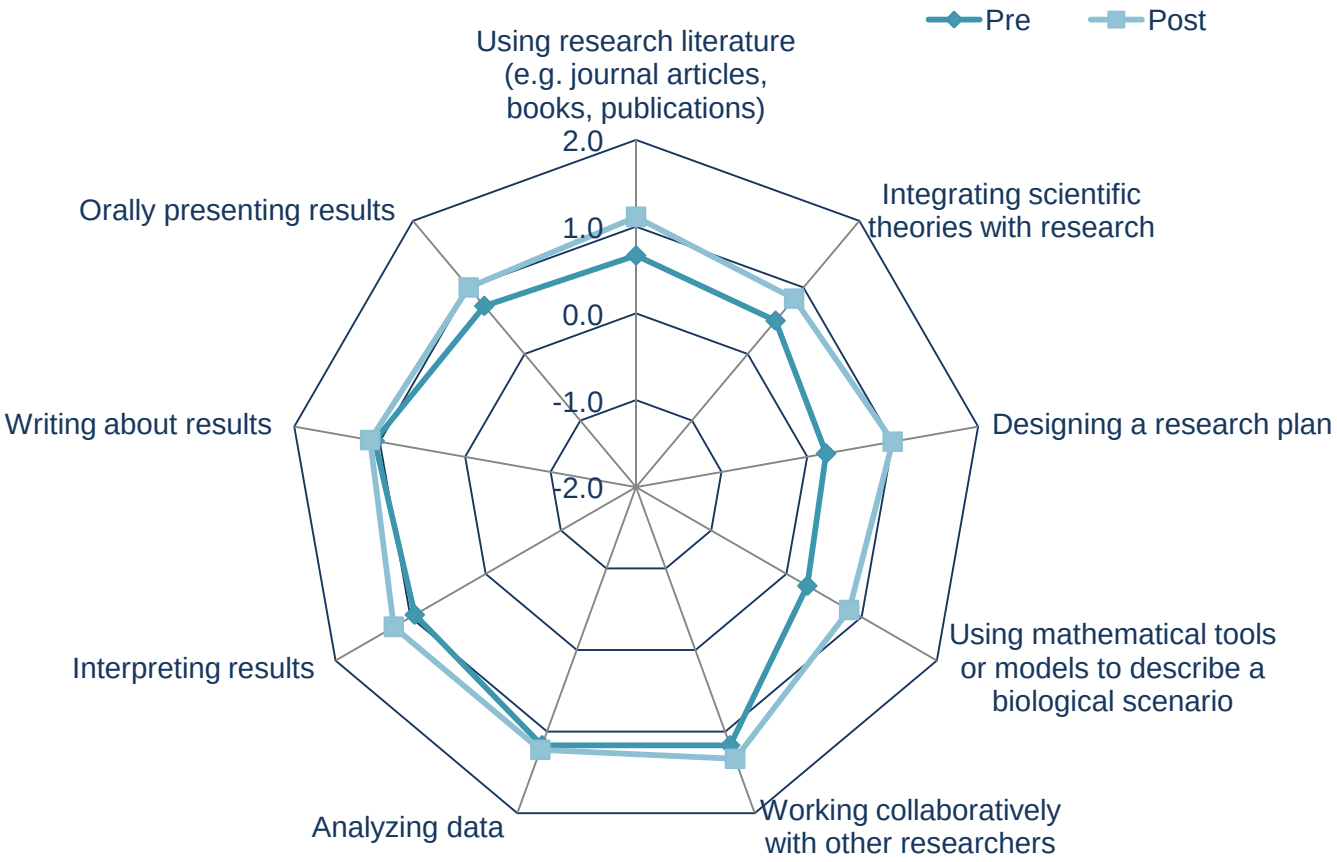


Program Impact

Participant Skills

Participants were asked several questions before and after participating in the program to gauge how well they felt they could carry out several research-related skills. Analysis of pre and post responses showed that gains were reported in every skill on the survey, with an average rating for all skills at 0.75 on the pre-survey and 1.07 on the post-survey (on a 5-point Likert scale from -2 to 2 for extremely poor at the skill to excellent at the skill). Participants showed the greatest skill gains in designing research plans, using mathematical tools or models to describe a biological scenario, and using research literature. Other skills enhanced by participation in the program included integrating scientific theories with research, interpreting results, and orally presenting research results (Figure 9).

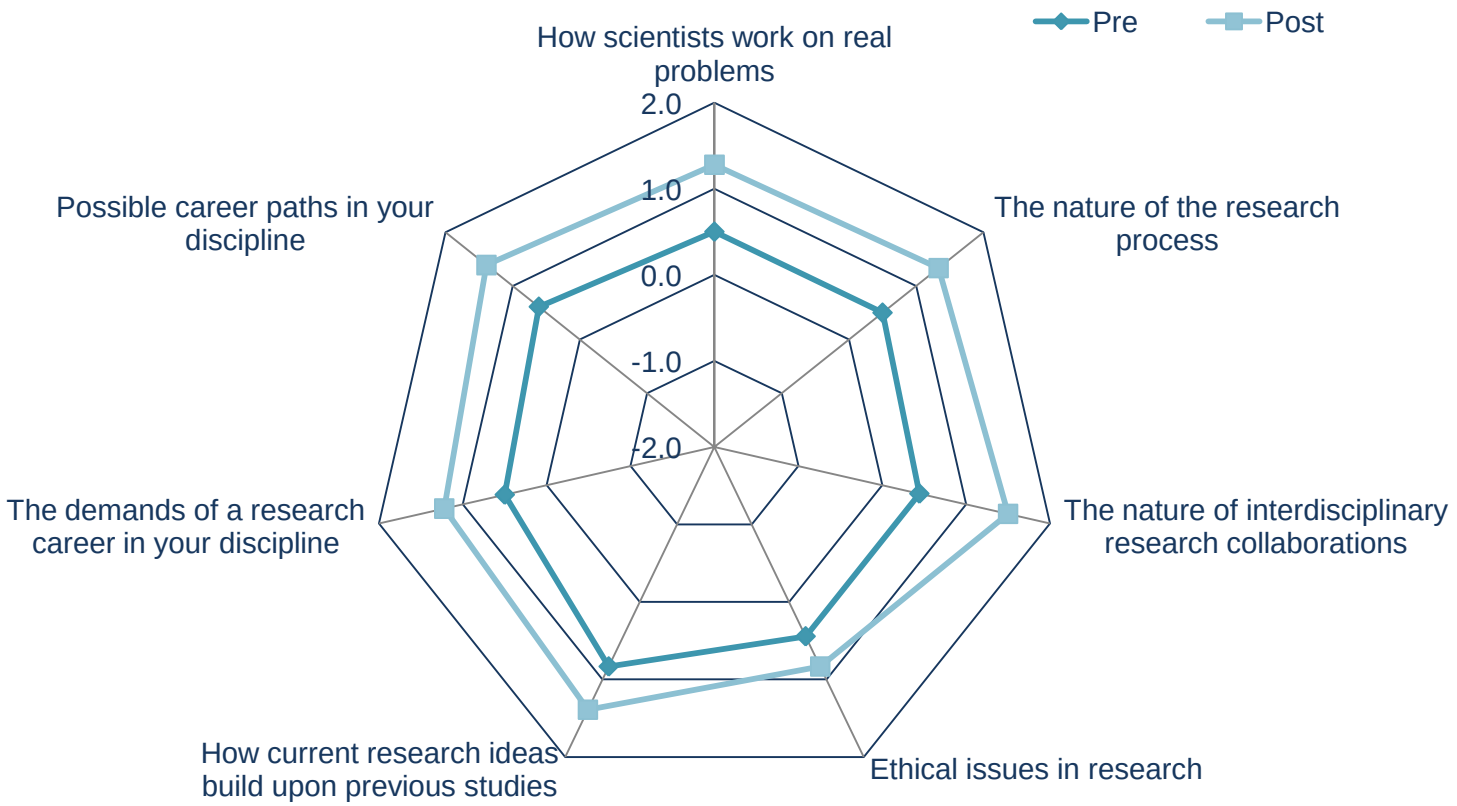
Figure 9. Participant pre-and post-program skills



Participant Knowledge

In addition to enhancing their research skills, participants also reported gains in knowledge about the research process. Participants were asked to rate their levels of knowledge about several research-related topics both before and after participating in the program. Before the program, participants on average rated themselves 0.55 on a 5-point Likert scale from -2 to 2 for extremely poor understanding of the topic to excellent understanding). After participation, the average rating was 1.28. Participants showed the greatest gains in understanding the nature of interdisciplinary research collaborations and the nature of the research process (Figure 10).

Figure 10. Participant pre- and post-program knowledge



Graduate School Plans

Sixty-seven percent of participants said that participating in the program impacted their plans to go to graduate school in some way. Three participants said that the experience reinforced their previous decisions to attend graduate school:

> *"I feel more sure of my decision to study something related to math in grad school. Also I might like to concentrate on computational mathematics instead of abstract, as I preferred before."*

"This experience helped reinforce my plan on going to graduate school. I am now more certain that graduate school is the right choice for me."

"With the panels organized, I was better able to make a decision for my future concerning my current field and what I would want to study in graduate school. The panels were very helpful."

Others said that the experience made them more interested in integrating math and biology into their graduate school plans:

"I am already scheduled to begin grad school for math in the fall. This program has made me think more about integrating both math and biology/ecology into my future research as opposed to studying pure math."

"It gave me a better idea of what I want to study. I was thinking about applied Math before and after the program, I confirmed this interest and started leaning toward Math Biology."

A few participants indicated that they learned more about opportunities and issues related to graduate education:

"I had the opportunity to meet professors and other graduate students to discuss my plan of going to graduate school. I received suggestions on applying to graduate schools. I also learned about life as a graduate student from other graduate students which was pretty helpful."

"I learned a lot about the opportunities and the procedures related to graduate school application. The lectures and discussions about it helped a lot. Also, I talked to professors and explored the areas of grad school that I would be interested in and that are available at UTK and at other universities. I also met peers who are looking for grad school and talking to them was also a big impact on my plans for graduate school."

"The grad student panel made grad school related issues more clear."

Participants were asked the highest level of education they planned to complete both before and after participating in the program, and if participation in the program impacted their plans to attain graduate degrees. Results showed that all 18 of the participants planned on attaining graduate degrees before participating in the program, while 17 planned on graduate school after the program. Thirteen of the 15 participants who planned to obtain a Ph.D. before the program did not change their minds after participation; however, the remaining two decided to pursue a lesser degree after participating. One of three participants who planned to pursue a master's degree before participation kept his/her decision the same after participation; however, the other two indicated that participating in the program led them to want to pursue a Ph.D. instead of a master's degree (Table 2).

Table 2. Participant pre- and post-program graduate school plans

		End of program			Total
		Bachelor's	Master's	Ph.D.	
Start of program	Master's	0	1	2	3
	Ph.D.	1	1	13	15
Total		1	2	15	18

Conclusions and Recommendations

According to participant data, the REU/REV program was successful. Overall satisfaction with the program was high, with 94% of participants being "satisfied" or "very satisfied" with their experiences. Seventeen of the 18 participants also indicated they would recommend the program to others. The majority of participants said the program met or exceeded their expectations, and that the workload was appropriate for the program. Participants were also highly satisfied with their mentors, indicating that they were skillful, helpful, and positively impacted the research experience overall.

Participants showed high levels of satisfaction with the accommodations offered during the program, with the majority being highly satisfied with computing resources, extracurricular activities, housing, and mail service. Several participants suggested providing a gym pass to the student recreation center for participants in the future.

Several information sessions organized in conjunction with UT's Department of Biochemistry and Cellular and Molecular Biology (BCMB) were rated highly by participants. Participants were asked to rate the usefulness of these sessions on a scale of -1=not useful to 1=very useful. Ratings for the sessions ranged from an average of 0.11 for the "Diversity in Science" session, to an average of 0.44 for the "Speaking to a Professional Audience" session.

Participants showed increased levels of confidence regarding how well they felt they could carry out several research-related skills. Analysis of pre and post responses showed that gains were reported in every skill on the survey, with an average rating for all skills at 0.75 on the pre-survey and 1.07 on the post-survey (on a 5-point Likert scale from -2 to 2 for extremely poor at the skill to excellent at the skill). Participants showed the greatest skill gains in designing research plans, using mathematical tools or models to describe a biological scenario, and using research literature.

Participants also showed increased levels of knowledge about the research process. Before the program, participants on average rated themselves 0.55 on a 5-point Likert scale from -2 to 2 for extremely poor understanding of the topic to excellent understanding. After participation, the average rating was 1.28. Participants showed the greatest gains in understanding the nature of interdisciplinary research collaborations and the nature of the research process.

Sixty-seven percent of participants said that participating in the program impacted their plans to go to graduate school in some way. Three participants said that the experience reinforced their previous decisions to attend graduate school, while others said that the experience made them

more interested in integrating math and biology into their graduate school plans. All 18 participants planned on attaining graduate degrees before participating in the program, while 17 planned on doing so after the program. Thirteen of the 15 participants who planned to obtain a Ph.D. before the program did not change their minds after participation; however, the remaining two decided to pursue a lesser degree after participating. One of three participants who planned to pursue a master's degree before the program kept his/her decision the same after participation; however, the other two indicated that participating in the program led them to want to pursue a Ph.D. instead of a master's degree.

Based on analysis of participant response data, the recommendations are as follows:

- The program appears to be on-track—no major changes to content or format are needed.
- Several participants felt the career panel did not apply to their career goals. Consider representing more diverse careers on the career panel—specifically those working in veterinary research and mathematics.
- For future implementations of the program, consider the feasibility of offering participants a pass to the student recreation center.

Appendix A

List of Participants

Participants

Last name	First name	Institution
Adhikari	Samrachana	Mount Holyoke College
*Armsworth	Paul	NIMBioS, UTK
*Bewick	Sharon	NIMBioS
Bodiroga	Dubravka	Hood College
Bulger	David	Oral Roberts University
Collins	John	University of Tennessee Knoxville
Drakes	Crystal	Kansas State University, College of Veterinary Medicine
*Eda	Shigetoshi	University of Tennessee Knoxville
Geyer	Kelly	Virginia Polytechnic Institute and State University
*Godsoe	William	NIMBioS
*Gwinn	Kimberly	University of Tennessee Knoxville
Jackson	Ashley	North Carolina A&T State University
*Joo	Jaewook	University of Tennessee Knoxville
Kelemen	Reka	Iowa State University
Lancaster	Evan	Blackman High School
*Lenhart	Suzanne	NIMBioS, UTK
Massaro	Tyler	State University of New York Geneseo
*New	John	University of Tennessee Knoxville
Nguyen	Luong	Mount Holyoke College
Ojogbo	Ejebagom	Fisk University
Rekant	Steven	Virginia Polytechnic Institute and State University
Scott	Janelle	Kansas State University
Spence	Meredith	North Carolina State University

Thai	Ngoc	Truman State University
Trask	Jillian	Bearden High School
Wise	Steven	University of Tennessee Knoxville
Yang	Guang	Appalachian State University

*** Organizer**

Appendix B

REU/REV Pre and Post-surveys

Research Experiences for Undergraduates/Veterinary Students

Pre-survey

Thank you for taking a moment to fill out this survey. Your results will be used to enhance your experience at the University of Tennessee this summer, to improve the REU/REV programs for future cohorts, and to track your progress during the program. Congratulations on your acceptance into the program. We hope you have an interesting and exciting experience.

How did you learn about this program?

What do you hope to gain through participation in this program?

What is the highest level of education you have completed to date?
High school diploma
Associate's degree
Bachelor's degree
Master's degree
Doctoral degree
Other degree, specify:

Are you currently enrolled in a degree-granting program?
Yes
No

What type of degree are you currently pursuing?
Associate's degree
Bachelor's degree
Master's degree
Doctoral degree
Other degree, specify:

What is the highest level of education you hope to complete?
High school diploma
Associate's degree
Bachelor's degree
Master's degree
Doctoral degree
Other degree planned, specify:

The questions on this page will be used to track your progress as a researcher during the program. It's okay if you don't feel as though you have strong skills in all areas.

How would you rate your ability regarding the following research skills?
{Extremely poor, Below average, Average, Above average, Excellent }

Using research literature (e.g. journal articles, books, publications)
Integrating scientific theories with research
Designing a research plan
Using mathematical tools or models to describe a biological scenario
Working collaboratively with other researchers
Analyzing data
Interpreting results
Writing about results
Orally presenting results

The questions on this page will be used to track your progress as a researcher during the program. It's okay if you don't feel as though you have a good understanding of all the subjects listed.

How would you rate your level of understanding in the following areas?
{Extremely poor, Below average, Average, Above average, Excellent }

How scientists work on real problems
The nature of the research process
The nature of interdisciplinary research collaborations
Ethical issues in research
How current research ideas build upon previous studies
The demands of a research career in your discipline
Possible career paths in your discipline

Please give any suggestions for activities you would like for us to do as a group (social and/or research related):

Please use this space for any additional comments:

Research Experiences for Undergraduates/Veterinary Students

Post-survey

Thank you for taking a moment to fill out this survey. Your results will be used to improve the REU/REV programs for future cohorts, and to track your progress during the program. We hope you had an interesting and exciting experience!

Overall Evaluation

Overall, how satisfied were you with your research experience?
Very satisfied
Satisfied
Neutral
Dissatisfied
Very dissatisfied

To what extent did this research experience meet your expectations?
No expectations met
Some expectations met
Don't know
Most expectations met
All expectations met or exceeded

How did you feel about your workload overall?
Way too little
Too little
Just about right
Too much
Way too much

Did this research experience impact your plans to go to graduate school?
Yes →Please explain how the research experience impacted your plans for graduate school:
No

What is the highest level of education you hope to complete?
High school diploma
Associate's degree
Bachelor's degree
Master's degree
Doctoral degree
Other degree planned, specify:

Please indicate how useful you found the following sessions, which were sponsored jointly with the Department of Biochemistry and Cellular and Molecular Biology (BCMB): *{Very useful, Somewhat useful, Not Useful}*

Speaking to a Professional Audience
Science Ethics
Diversity in Science
Career Opportunities
Graduate Student Question and Answer Panel

Comments about BCMB sessions:

Please list any other sessions or lectures you found valuable:

The questions on this page will be compared with your pre-survey answers to track your progress as a researcher during the program.

How would you rate your ability regarding the following research skills?
{ Extremely poor, Below average, Average, Above average, Excellent }

Using research literature (e.g. journal articles, books, publications)
Integrating scientific theories with research
Designing a research plan
Using mathematical tools or models to describe a biological scenario
Working collaboratively with other researchers
Analyzing data
Interpreting results
Writing about results
Orally presenting results

The questions on this page will be compared to your pre-survey answers to track your progress as a researcher during the program.

How would you rate your level of understanding in the following areas?
{Extremely poor, Below average, Average, Above average, Excellent}

How scientists work on real problems
The nature of the research process
The nature of interdisciplinary research collaborations
Ethical issues in research
How current research ideas build upon previous studies
The demands of a research career in your discipline
Possible career paths in your discipline

Would you recommend the NIMBioS REU/REV program to others?
Yes
No → Please explain why you would not recommend the NIMBioS REU/REV to others:

Please use this space for any additional comments about your research experience overall:

Accommodations Evaluation

Please indicate your level of satisfaction with the following accommodations provided to you during your research experience:
{ Very satisfied, Satisfied, Neutral, Dissatisfied, Very dissatisfied, Not applicable}

Computing resources
Housing
Mail service (postal)
Extracurricular activities

Did you find the Wiggio was a useful means of communicating within the REU/REV group?
Yes
No
I did not use the Wiggio
I did not know about the Wiggio

Please describe any accommodations/supports you needed that were not supplied (if any):

Mentor Evaluation

Your responses to the following questions will be kept confidential. Your name will not be associated with any of your responses regarding your mentors during reporting. Please select the name of one of your mentors: (NOTE: This question was repeated twice, allowing participants to rate both of their mentors)
Armsworth, Paul
Bewick, Sharon
Eda, Shigetoshi
Godsoe, William
Gwinn, Kimberly
Joo, Jaewook
Lenhart, Suzanne
New, John
Wise, Steven

My mentor:
{Strongly agree, Agree, Neutral, Disagree, Strongly disagree}

Was accessible
Was interested in enhancing my research experience
Communicated on an appropriate level
Encouraged independence
Offered constructive ideas for improvement
Was organized
Had the necessary skills to mentor
Positively impacted my research experience

Please use this space for additional comments about your mentors:

Appendix C

Open-ended Survey Responses

PRE-SURVEY

How did you learn about this program?

A friend of a friend of a friend. Who was one of my math professors at Appstate.

A friend saw it in a weekly email and recommended it to me.

Another student from Kansas State University College of Veterinary Medicine sent out a mass email asking for students who would like to attend. She had previously participated with NIMBIOS.

Department list serve emails.

Dr. Suzanne Lenhart invited me at a NIMBioS conference last October.

Email from math department in Mount Holyoke College.

From a presentation given by NIMBioS representatives that came to Fisk University

From an email that I got from my academic adviser at Iowa State University.

From Mathematics Department, Mount Holyoke College

From one of my professors at my school.

I had an e-mail forwarded to me from a professor.

I learned about this program through Suzanne Lenhart.

My advisor recommended the program to me.

Online search engine for summer REU

The Chair of Math department at Hood College, Dr. Mayfield, printed out information with link to the website and suggested me to apply.

Through Judith Canner, a PhD candidate at NCSU that I had done research with.

Through my mentor, Dr. Gregory Goins, at NCAT.

Thru a friend who is in a graduate study program at University of Tennessee

What do you hope to gain through participation in this program?

I hope to expand my knowledge and abilities in the field of interdisciplinary research and modeling of natural phenomena.

I would like to gain knowledge on a veterinarian's role in Science and Research. I would also like to gain more knowledge about the diseases we would be studying as a whole.

In addition to gaining broad knowledge on the subject of biomathematics and specific knowledge in Johne's disease (which is my chosen topic), I hope to build friendships that will last even after the program.

I am hoping to get a feel for what it would take to make a career out of doing biomathematics research and modeling.

I'm very interested in veterinary epidemiology, so I hope to gain a better perspective of what a career in that field would entail.

I hope to learn more math skills. I hope to gain confidence that I can use math not just in class but in "real life" situations. Also, I hope to have fun learning about non-mathematical aspects of the research, such as biology, and to reach amazing and useful results that will be helpful in wider scope. And finally, I hope to meet great people and make lasting friendships and connections.

Team work skill, programming skills, knowledge about applied Math

Through participation in this program I hope to gain experience in the research and application of mathematics. I have taught for the past four years and I am now interested in learning new ways to apply math outside the classroom, particularly to other disciplines.

A new research experience in a professional setting.

Additional knowledge in my area of study, experimental and research experience, and experience in a field that is different from my own (broadening my scopes).

Experience in researching.

Experience researching and using applied math to solve problems.

Experience with epidemiology and research, hopefully to apply to a future career in public health.

I hope to gain some experience in research in the field of statistics and biodiversity. I also look forward to working on and exploring interesting research topics that will possibly lead me to my honor thesis next year.

I hope to gain some research experience and some insights into the workings of mathematical modeling that will serve me well in my pursuit of my PhD. I also hope to network with professors and researchers at the top of the field of math ecology.

I hope to gain some research experience in the field of biology and hopefully bioinformatics, too. I am interested to see the University of Tennessee and the NIMBioS. I hope to gain some friends over these two months too.

Research experience, grad school opportunities, making friendship

Valid, hands-on experience which will bring me one step closer to reaching my career goals.

Other degree planned, specify:

Doctoral if I can't find a job after getting a Master's

Please give any suggestions for activities you would like for us to do as a group (social and/or research related):

At least one day take us to tour Nashville. As an international student I really enjoy learning about different cities and it would be sad to not experience that while in Tennessee.

Bowling!

having speakers over for lunch where people can casually chat about a specific research topic

I believe that you have hikes planned already, which I think will be fun. Since I am not well-versed in the research side of mathematics, I would like to see workshops that give us some instruction on the matter, though, I believe you have some of this planned as well.

I would LOVE a guided tour of ORNL if that's possible. I think it would be good to see and meet people who are already at the cutting edge of research.

Interactions between participants of different research groups will be helpful. Few sessions on applying to graduate school and career paths will be useful to students who are either thinking of applying to grad school or working in the field.

Mountain climbing.

Personally, I would enjoy finding great picnic spots and hiking in the GSMNP.

Pot-luck or cookout, hiking, talks from veterinarians working on similar issues

Since Tennessee is, as I heard, very beautiful, I would suggest outdoor activities, such as hiking, sightseeing, camping, kayaking, picnics, etc. Maybe we could play social games together, too. It would be fun since there are many of us.

Some sort of sporting activity like soccer or frisbee.

Visit research labs of different scientific areas, like genetics, immunology, etc.. It would be good to watch movies or documentaries about scientists or researchers, anything that is related somehow to our research area.

Please use this space for any additional comments:

I am thoroughly looking forward to this summer research experience.

I checked out hundreds of researches and internships. Most of them did not accept American non-citizens or they were unpaid, in distant locations, which I could not afford to travel to. My adviser found three perfect ones to apply and I consulted two other math teachers, too. They said that this was the best opportunity I can get and they were excited talking about the University, Tennessee, offered research topic, choosing their favorite ones, before I even told them I would apply there. I definitely agree with them. And also, it is just like created for me, because I am an international, I love math, I want to do a research, I love people, and I love nature.

POST-SURVEY

Please explain how the research experience impacted your plans for graduate school:

I am very interested in pursuing a Masters in Public Health or concentrating on epidemiology. Our summer research helped me gain another perspective on how I could focus on these interests.

I had the opportunity to meet professors and other graduate students to discuss my plan of going to graduate school. I received suggestions on applying to graduate schools. I also learned about life as a graduate student from other graduate students which was pretty helpful.

I learned a lot about the opportunities and the procedures related to graduate school application. The lectures and discussions about it helped a lot. Also, I talked to professors and explored the areas of grad school that I would be interested in and that are available at UTK and at other universities. I also met peers who are looking for grad school and talking to them was also a big impact on my plans for graduate school.

the grad student panel made grad school related issues more clear

After spending the summer doing research I now want to go to graduate school.

Prior to the REU, I was debating between grad school and med school, and this tipped the scales in favor of grad school.

I am already scheduled to begin grad school for math in the fall. This program has made me think more about integrating both math and biology/ecology into my future research as opposed to studying pure math.

It gave me a better idea of what I want to study. I was thinking about applied Math before and after the program, I confirmed this interest and started leaning toward Math Biology.

During the research experience, Lou Gross introduced me to John Koontz, a biochemistry professor at UTK. Dr. Koontz informed me about the Translational Medicine aspect of the MD/PhD programs I am applying to.

I feel more sure of my decision to study something related to math in grad school. Also I might like to concentrate on computational mathematics instead of abstract, as I preferred before.

This experience helped reinforce my plan on going to graduate school. I am now more certain that graduate school is the right choice for me.

With the panels organized, I was better able to make a decision for my future concerning my current field and what I would want to study in graduate school. The panels were very helpful.

Please describe any accommodations/supports you needed that were not supplied (if any):

I wish we had more trips to Smokies.

I would have been nice to have a meal plan.

It would have been nice to have gym access paid for.

no sauna in the gym :(

The only things that immediately jump out are parking and gym passes. Parking passes obviously are optional, but I think the BCMB group had gym memberships paid for and we didn't. Not that big of a deal though.

There were no loaner laptops for REU students.

Please use this space for additional comments about your mentors:

Both Dr. Lenhart and Dr. Eda were incredibly helpful, and always went out of their way to make sure that any questions I had were answered quickly and correctly. They are extremely professional, and it would be a shame if someone did not recognize the skills and experience they had to offer for us.

Dr. Joo was very straight to the point, told me what I did good and what I did not. This matches well with my working style. Dr. Gwinn is really awesome. I have not met such an encouraging and understanding professor before. She is someone who I definitely want to work with if I studied her field. I really enjoyed working with her.

Dr. New and Dr. Lenhart were excellent mentors for our research. I especially appreciated being able to talk to them about my own research interests. They gave great advice about further degrees and career opportunities. Dr. New and Dr. Lenhart both went out of their way to make us feel welcome and comfortable in Knoxville. They encouraged us to get out and experience everything that the city had to offer.

I believe that for the next NIMBioS project, information about each particular project should be made more available and explicit to the students e.g. I would have benefited from receiving information about mathematical models relating to disease simulation before I arrived at NIMBioS.

I had no skills to work in the lab, and Dr. Gwinn did a great job of teaching us how to do the lab work. We learned fast and she was very supportive and patient.

I'm looking forward to working with my mentors more throughout the upcoming year. Excellent mentors!

Kim Gwinn was an amazing mentor, she was very much interested in not only making this program an important milestone in our education but also in making our experience at the UTK this summer one of the most memorable memories in our student years.

they were very helpful and knowledgeable on our research topic

They worked very well together and were able to bring out the strengths in every member of the team.

Will and Paul were amazing! They were very supportive in everything that we did. They were great at giving us enough information to get us going and then being a little more hands-off until we requested help. I think that they really helped us to grow as independent researchers while also keeping things structured.

Please explain why you would not recommend the NIMBioS REU/REV to others:

I don't know anyone who would be interested in this program.

Comments about BCMB sessions:

Graduate Student Panel was very informative and useful and I liked how we could fully participate and address our specific issues and questions...

I found all of these sessions worth attending and all the speakers were well selected and well prepared and very helpful. I think it was a great thing for all of us, students, to get the chance to just attend all these well organized and well planned events.

Several of the undergrads told me that they found "Career Opportunities" and the Grad student panel to be very helpful for them. However, since I'm already in veterinary school these two programs didn't really apply to me.

The "Career Opportunities" panel was not very useful because it seemed the majority were from the lab. As a mathematician, I highly doubt I will be doing a career in the lab doing chemistry research. There was not a good diversity of mathematics or industry workers.

They were useful, but seemed more geared to younger participants, not those of us already in graduate school.

Please list any other sessions or lectures you found valuable:

I enjoyed the lecture given by Dr. Shigetoshi Eda on Johne's Disease as it discussed issues that are important to me as a future veterinarian.

I learned a lot from Dr. Lenhart's Modeling Lectures.

I really enjoyed the mathematical modeling lectures that Suzanne gave throughout the summer, as well as watching the math REU presentations at the end of the summer.

Math modeling by Dr. Lenhart

Modeling lessons captured all main points of modeling and was a great way to go over things we learned in class.

The lectures on how to use the software that we were given, and the lectures that explained some mathematics concepts I was yet to visit.

The modeling lectures were also very helpful.

Please use this space for any additional comments about your research experience overall:

Excellent research experience! I am planning to continue the research to hopefully publish and present our results.

I enjoyed the group, I think the program drew together people who all wanted to make the social side

of things work and therefore it did.

I felt great about this research experience because I was never overwhelmed with work, I always had time to enjoy the summer with my fellow students, but on the other hand, I was part of a serious and professional research. I worked and learned and gained a lot by being in Kim Gwinn's research group while having a great time in Knoxville.

I learned how a research process looks like and how to be creative to plan the research and come up with the method of research.

I love it. All the participants made it an enjoyable experience. I played soccer almost every week and we had 4 birthday parties. All are very great.

I really wish that there had been some hands-on work for the biology side of things. The math research experience was great, but I feel that the biology side was a bit lacking, other than the models being applied to biological scenarios.

I think the research experience was very good but I think a veterinary student with a stronger interest in epidemiology and mathematical models than myself would have benefited from it more. My favorite moments were when I was allowed to work outside of the classroom e.g. the visits to the dairy farm or writing the research paper. I think that this research project helped to clarify my interests in veterinary research and I appreciate more the mathematical aspect of biological research.

Thank you, NIMBioS, for an awesome summer!

This was such a great experience; one that really opened my eyes, in more ways than one. I am much more aware of the wonders of biology that I see every day and am SO much more interested in applying math to biological/ecological situations. I really appreciate the opportunity to have participated in such a program.

very enjoyable