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## Lessons Learned from ToxMSDT: A Pilot Innovative Toxicology Research Education Pipeline Program Targeting Underrepresented Undergraduate Students to the Field of Toxicology

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### Abstract

Toxicology, as a profession, lacks diversity. Undergraduate students, and especially underrepresented students, are not commonly introduced to toxicology at US colleges and universities. The Toxicology Mentoring and Skills Development Training Program (ToxMSDT) seeks to acquaint underrepresented undergraduates enrolled in STEM fields with toxicology fundamentals and skills to aid their entry into graduate programs and, ultimately, careers in toxicology. ToxMSDT is a collaboration among three universities. It is a year-long holistic training and mentoring program comprised of web resources accessible 24/7 and extensive one-to-one mentor-mentee interactions throughout the year. Evaluation of the two-year pilot program shows that students expressed a significant increase in knowledge about toxicology careers, networking with people involved in the field of toxicology, feelings of being part of the toxicology community, and seeing themselves as someone who will study toxicology, compared with their feelings prior to their participation in the ToxMSDT program. Thirty students have completed the ToxMSDT program and all 10 (100%) of those who have graduated have joined graduate school in toxicology or toxicology-related STEM fields. Of the 20 (66.6%) program alumni still enrolled as undergraduates, five (25%) are in the process of applying to graduate programs and medical schools as of August 2019.

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### Introduction

There are significant challenges facing the recruitment and training of the nation's biomedical, behavioral, and clinical research workforce to meet needs in the 21<sup>st</sup> century, especially with regard to diversity. The challenge is having an inclusive workforce that reflects the diversity of the American population across racial, gender, ethnicity and economic spectrums so that the variety and disparity in diseases can be recognized and adequately addressed. Underrepresented individuals (African-Americans, Hispanic-Americans, Native Americans, Alaska Natives, Native Hawaiians, Native Pacific Islanders)

receive fewer baccalaureates and PhD degrees in fields of science as compared to whites overall (Gibau et al., 2010; Coronado et al., 2012), and therefore are deserving of special attention for workforce diversification in areas of interest to the National Institutes of Health.

In the next 50 years, the minority population (African-Americans and Hispanic-Americans) will become the majority in the US (Hayes, 2010), yet at present, minorities are disproportionately underrepresented in the biomedical workforce. This may limit the recognition of disease disparities in different segments of the US population, such as for African-Americans who are more likely to die from prostate cancer, breast cancer, diabetes and cardiovascular diseases than the population in general. Additionally, there are well-recognized racial, gender, ethnic and economic disparities in the incidence of a broad range of environmental health-related diseases that are not uniformly expressed across all segments of society. Economic disparities have led to the disproportionate exposure of economically depressed neighborhoods to toxic environmental chemicals (Olden & White, 2005; U.S Department of Health and Human Services, 2012). For example, minority groups who live in low-income neighborhoods are more likely to be exposed to certain environmental toxicants, such as lead, than those living in more affluent neighborhoods (Cureton, 2011).

Additionally, it has been shown that minorities are exposed to higher concentrations of toxic chemicals (phthalates, naphthalene, and carcinogenic heterocyclic aromatic amines, among others) than other segments of the US population (Ji et al., 1994; Silva et al., 2004; Sudakin, Smit, Cardenas, & Harding, 2013). Furthermore, because of genetic differences, minorities may respond differently to some chemical exposures than the population-at-large. For instance, African-Americans, especially African-American women, have a significantly reduced activity of the enzyme which metabolizes 5-fluorouracil (5-FU), a common colon cancer chemotherapeutic. Therefore, African-Americans experience lower overall survival of colon cancer compared to Caucasian patients, due to associated 5-FU toxicity, when 5-FU is used for treatment of colon cancer (Mattison et al., 2006).

Genetic backgrounds and life experiences of individuals can shape career choices and produce motivating factors that lead individuals to select areas of scientific research or career paths (Hayes, 2010). Many individuals who have been impacted by specific diseases or environmental contaminants may be motivated to pursue research in search of answers to help their families or communities; this ultimately helps the entire nation. However, underrepresented individuals may not be fully aware of the specific research disciplines and opportunities that exist to address problems impacting the health and well-being of their families, communities and the nation.

Toxicology represents a scientific discipline that addresses issues of human health in response to chemical, physical or radiation exposure. However, the dearth of toxicologists from ethnic minority and broader underrepresented backgrounds creates a gap in expertise, mentoring, and role modeling that would facilitate minority recruitment into toxicology training programs and subsequently into the profession. One of the problems facing the toxicology profession is that toxicology is not widely taught at the undergraduate level in most colleges and universities in the US. Therefore, toxicology as a career may not

be recognized and chosen by most underrepresented STEM students. Introducing these students to the discipline of toxicology early in their undergraduate training may positively impact the number of underrepresented students who become interested in toxicology, enter graduate school toxicology training programs, and ultimately choose toxicology as a career. Scientists of such backgrounds can contribute to the diversity of the toxicology workforce and serve as role models to future generations.

Toxicologists study the adverse effects of chemical, physical or radiological agents on people, animals and the environment and thus play important roles in human, animal, and environmental health (Barchowsky et al., 2012; Rumbeiha, 2012). Toxicology is a practical health profession that impacts our daily lives, as well as the well-being of animals and our environment. Toxicology is also a highly multidisciplinary field, drawing scientists with diverse expertise from across the STEM fields. As such, toxicology is rich with multiple specializations, such as occupational health and safety, medical toxicology, veterinary toxicology, ecotoxicology, environmental toxicology, and forensic toxicology among others. It is estimated that there are about 9,000 toxicologists in the US workforce today, spanning different occupations in industry (47%), government (14%), academia (21%), research foundations, and as self-employed consultants (Society of Toxicology, 2020). The pharmaceutical, chemical and consumer product industries employ the majority of industrial toxicologists, who principally are involved in translational research. Government is also a substantial employer of toxicologists who work at local, state and federal levels. Government toxicologists are concerned primarily with regulatory toxicology, but may also conduct research. In academia, toxicologists educate future generations of toxicologists and are also engaged in basic, clinical and translational research.

The toxicology profession has long recognized that the nation's toxicology workforce does not reflect our national diversity (Barchowsky et al., 2012). For over 20 years, the Society of Toxicology (SOT), the largest toxicology organization in the world, has conducted an undergraduate minority training program with funding from the NIH Minority Access to Research Careers program, in an effort to address the lack of minorities in toxicology (Society of Toxicology, 2009). This program continues to engage more than 35 meritorious minority undergraduate students and undergraduate advisors annually, who participate in specialized programming in conjunction with the SOT annual meetings. This highly visible program has scored some success, but this and related programs have yet to close the gap in terms of increasing the presence of toxicologists from underrepresented minority backgrounds in the toxicology workforce. The diversity of professionals in federally-funded health research in general, and in toxicology specifically, remains disappointingly low (Barchowsky et al., 2012).

We describe here the outcomes of a two-year pilot program that seeks to mentor and train underrepresented undergraduate students in toxicology in order to create a pathway for students entering graduate school and ultimately moving into the toxicology workforce. This effort, the Toxicology Mentoring and Skills Development Training (ToxMSDT) program, targets STEM-focused underrepresented undergraduate students for mentoring and skills development to motivate their choice of toxicology as a career path and to provide them with the needed resources and skills to increase their competitiveness for entry into the discipline.

A secondary objective is to increase the numbers of underrepresented individuals entering other areas of NIH interest, e.g. behavioral and medical fields. We focus on STEM students because of their commitment to science careers. We also focus on undergraduates because undergraduate training in toxicology is rare in the US, and this is the stage of their training where we can make the most impact.

## Methods

### Design Principles.

The ToxMSDT program uniquely targets training in ways different from existing undergraduate mentoring and training programs in the field of toxicology. First, because we recognize that many promising students with interests and abilities in STEM are not necessarily drawn to careers as research scientists, we focus on introducing students to the vast array of post-graduate career choices in toxicology, most of which lie outside of the research laboratory. Rather than emphasizing research experiences as found in existing, high-quality programs elsewhere (e.g., Research Experiences for Undergraduates funded by the National Science Foundation; SOT Undergraduate Education Program for Minority Students [www.vetmed.vt.edu/departments/dbsp/docs/Ehrich\\_SOT.pdf](http://www.vetmed.vt.edu/departments/dbsp/docs/Ehrich_SOT.pdf)), we create an environment where they are exposed to and gain tangible experiences with various toxicology-related careers.

Second, we recognize that many underrepresented students are unfamiliar with toxicology as a discipline and may lack networks of peers and role models who have knowledge of the discipline or of associated toxicology careers. We therefore match students with mentors who engage extensively with their mentees in both face-to-face and virtual settings over a one-year period, with the intent of forming long-term relationships that can serve as sources of guidance, expertise and networking for the students. This is a very different mentoring opportunity than the aforementioned SOT undergraduate minority program, which offers mentoring and high-quality programming, but over a much-condensed timeframe. Our mentors are experts drawn largely from industry and government, which helps to achieve our goal of introducing students to post-graduate careers that the students may anticipate outside of academia. The career paths of our mentors are principally related to translational research, consulting and regulatory toxicology, but we also provide mentors from academia for those students who express interests in basic and clinical research careers. Finally, mentees from both cohorts were introduced to the various discrete elements of the ToxMSDT program through the following program activities:

- Attending a two-day Kickoff Workshop held at Iowa State University where mentees are introduced to their mentors as well as leaders in the field of toxicology, training in the responsible conduct of research, qualities of a good mentee and mentor, an overview of the toxicology profession, and an orientation to the online learning modules developed by the program.
- “Two Days in the Life of a Toxicologist” Experience at the mentor’s worksite. The immersion of the students in the actual workplace of their mentor

provides the students with an opportunity for case studies and shows them how toxicologists make decisions which protect human health.

- Attending the SOT's Undergraduate Diversity Program, along with other sessions at the SOT's Annual Meeting in mid-March, where mentees interact with other students and mentors, and are exposed to various internships and summer research experience opportunities for undergraduates in toxicology and related fields like Summer Research Early Identification Program (SR-EIP), BioMedical Summer Undergraduate Research Fellowship (BioMed SURF), etc.
- Participating in a Capstone Event at Tuskegee University in late spring, where all mentees give an oral presentation about their program experiences to mentors, fellow mentees, the Program Advisory Committee, and to interested undergraduate and graduate students from Tuskegee University and surrounding colleges and universities. Also, students participate in a focus group led by an external program evaluator. At the conclusion of this event, certificates of completion are awarded only to mentees who have met all criteria for the training program over the year.
- Completion of six online learning modules available 24/7 at <http://www.toxmsdt.com/e-modules.html>. These modules support skills development on topics ranging from pathophysiology, biochemistry and molecular genetics to regulatory toxicology.

Collectively, the ToxMSDT program aims to prepare its students to be competitive in the application process to enter graduate toxicology programs.

### **Online Skills Development Course.**

The SOT Toxicology Education Summit (Barchowsky et al., 2012) recommended that skills development should emphasize applied exercises of toxicology principles, use case studies, and develop industry partnerships. This program has developed and delivered content that expressly addresses topics identified as generally deficient in preparing successful toxicologists. For this pilot project, students were first required to complete an online training in the responsible conduct of research (CITI Basic Course), and two hours of in-class training in research and medical ethics. Subsequently, students were asked to complete a primer on principles of toxicology (ToxTutor from the National Library of Medicine <https://toxxtutor.nlm.nih.gov/index.html>), followed by six online learning modules (ToxMSDT, Online Learning Modules <http://www.toxmsdt.com/>), which were developed *de novo* for the program. These modules support skills development on topics ranging from pathophysiology, biochemistry, and molecular genetics to regulatory toxicology. The modules were designed based on learning design principles and learning theories. They are highly interactive, featuring visuals and embedded quizzes designed to enhance student learning and support self-regulated learning.

Students are required to take a final assessment at the end of each online module and must achieve a passing grade. The final assessment was set up to allow three chances for the students to return and study the module again and repeat the test until the passing grade of

80% is obtained. These modules were developed based on expert content drawn from among the mentors, all of whom were from industry and government, and designed by a member of the Program Advisory Committee (PAC). This is an example of an industry-academia partnership. The Program Advisory Committee (<http://www.toxmsdt.com/pac.html>) is a diverse group of scholars from different ethnic backgrounds (3 African Americans, 2 Caucasians and 1 Hispanic) and with various areas of technical expertise, including education, toxicology, pathology, bioethics, learning design, and statistics.

### **Mentor Demographics.**

A strong mentor-mentee relationship is essential for the achievement of short-and long-term goals and positive progression toward a profession (Byington, 2010). A total of 23 mentors from different disciplines as shown in Table 1 were recruited, vetted, and matched one-to-one with undergraduate mentees on the basis of life experiences and interests to foster a strong mentor-mentee relationship. Mentor-mentee matching was done by the program advisory committee based on a survey questionnaire completed by mentees and mentors. The strength of ToxMSDT is that mentors come from diverse backgrounds in industry and government and represent many toxicology disciplines. Mentors agreed to a one-year commitment with three fixed dates for face-to-face meetings and a two-day site visit by the mentee to the mentor's workplace.

All mentors were given a two-hour formal training on mentoring relationships at the beginning of the course, at the inaugural workshop by the Leadership and Mentoring Institute, which is run by the American Association of Blacks in Higher Education. They were also provided resource contacts and guidance on conflict resolutions. Some of the mentors had prior formal and informal experience in mentoring undergraduates.

### **Mentee Demographics.**

ToxMSDT program recruited and trained a total of 30 mentees over <sup>nd</sup> cohort the two year-pilot phase, 15 mentees for each cohort (class of 2017, referred to as 1<sup>nd</sup> cohort). This recruitment targeted minority male and female and class of 2018, referred to as 2 undergraduate students who were enrolled in various STEM fields with GPAs of 3.0 or higher, and who expressed interest in exploring careers in toxicology or other health-related careers. Table 2 shows the demographics of the mentees. A majority of the mentees were African-Americans and female. For the pilot phase, they were recruited predominantly from Tuskegee University and Iowa State University.

### **Conceptual Mentoring Framework.**

The program paired mentees and mentors at a 1:1 ratio, with the program advisory committee using responses to a questionnaire that was mailed out to both mentees and mentors. Every effort was made to accommodate needs of mentees. The program advisory committee considered suitable models for mentoring relationships including those of Young and Perrewé (Young & Perrewé, 2000) and Agholor et al, (2017). Because this was the first mentoring experience for most of the mentees and some of the mentors, we incorporated mentor and mentee training sessions at the program kickoff workshop on mentoring relationships and responsibilities. Separate training sessions were led by the President of

the Leadership and Mentoring Institute (LMI), which emphasized the responsibilities of both the mentor and the mentee in a mentoring relationship (Agholor et al., 2017; Byington, 2010; Young & Perrewé, 2000).

### **Pilot Program Evaluation.**

ToxMSDT was independently evaluated by a cognitive psychologist experienced in evaluating STEM recruitment and training programs emphasizing the recruitment of women and minorities into STEM fields. The immediate outcomes of the ToxMSDT program were evaluated through: confidential online surveys sent to mentees immediately after the Kickoff Workshop and in mid-May after the vast majority had completed all program activities (93% response rate for both surveys of the 2<sup>nd</sup> cohort); a one-hour, tape-recorded student focus group conducted by the evaluator at 1<sup>st</sup> cohort; 100% and 87% response rates for surveys of the 2 the end of each Capstone Event (100% participation rate in 2017, 60% in 2018 due to early departures); online surveys sent to mentors in mid-May after the vast majority had had their site visit with mentees (100% response rate the 1<sup>st</sup> cohort; 93% response rate for the 2<sup>nd</sup>); a one-hour, tape-recorded mentor focus group conducted by the evaluator at the end of 2018's Capstone Event (all mentors except the program director participated); and year-round review of program communications, documents and website materials. Pre and post survey responses were evaluated based on:

- Program main outcome measures
- Program activity measures
- Program benefit measures
- Post-program degree of interest
- Mentors' expectations measures
- Mentors' perception of program effectiveness and post program engagements.
- Follow-up surveys with all mentee alumni.

Each respondent's pre and post survey responses and responses between cohorts were compared using independent samples t-tests, with  $p < .05$  considered significant.

## **Results**

### **Program Main Outcomes.**

The ToxMSDT program's largest impacts were on the items where students had the most room for improvement. These are listed highest in Table 3a (1st cohort) and Table 3b (2nd cohort). Outcomes include how much students interacted with toxicologists and how much they felt being a part of the toxicology community. For the key question of how much "you see yourself as someone who will study toxicology," for the 1st cohort, this started out with a mean of 2.43 on the 1 to 5 scale (between "Very little = 2" and "Some = 3") and ended up an average of 1.29 points higher, for a mean of 3.71 (approaching "Quite a bit = 4"). For the 2nd cohort (2018's Mentees), the pre mean of 2.54 on the 1 to 5 scale (between "Very little = 2" and "Some = 3") improved by 1.38 points for a mean of 3.92 (approaching



“Quite a bit = 4”). In the end, 64% of 1st cohort Mentees and 69% of the 2nd cohort mentees reported seeing themselves as someone who would study toxicology. Four of these immediate post-program measures in both cohorts showed statistically significant increases at  $p < .01$  (Tables 3a and 3b). The lowest degree of change was on items in which students coming into the program already had high ratings for interest in a research career and in getting post-graduate degrees, so these items had little room for improvement.

### **Program Main Activity Measures.**

Outcomes of the program activities were measured on a 5-point scale with all 15 of the activities listed having a mean rating of at least 3.38 on the 5-point scale and all but four having means of at least 4.00 (“Quite a bit”) as shown in Table 4a (1<sup>st</sup> cohort) in 2017. The activities are listed from highest rated to lowest rated (Table 4a. 1<sup>st</sup> cohort and Table 4b. 2<sup>nd</sup> cohort). For the 2<sup>nd</sup> cohort all program activities received mean ratings of 4.00 or higher, with only one exception of “attending the In vitro Luncheon at SOT” (Mean = 3.33). The In vitro Luncheon activity was also the bottom four rated with a score of  $< 4.0$ . Comparisons of the two cohorts showed that no differences reached statistical significance. Visiting the other university-associated program and the 2 Days in the Life of a Toxicologist visit were rated the highest by the 1<sup>st</sup> and 2<sup>nd</sup> cohorts, respectively. Other highly-rated activities by both cohorts were hearing other students’ presentations at the Tuskegee University capstone event, and meeting other students interested in toxicology at the SOT conference.

### **Program Benefit Measures.**

To determine the benefit and impact of ToxMSDT program on mentees, students from both cohorts were surveyed using a 5-point scale as the pre/post measures for nine specific items. All nine outcome measures in Table 5a (1st cohort) got mean ratings of 4.00 or higher, with the top four program impacts being: understanding what a career in toxicology involves (4.79), forming connections with other students interested in toxicology (4.79), increasing your skill and confidence interacting with toxicology researchers (4.43), and learning about or meeting toxicologists you can relate to (4.36). For the primary outcome measure of “increasing your interest in a career in toxicology,” the mean was 4.14, with 79% of respondents saying the program helped do this “Quite a bit=4” (5 students) or “A great deal=5” (6 students).

The items that changed the most in 2018 (2nd cohort) are listed in Table 5b. All nine outcome measures got mean ratings of 4.23 or higher, with the top three program impacts being: learning about or meeting toxicologists you can relate to (4.85), understanding what a career in toxicology involves (4.77), forming connections with other students interested in toxicology (4.54). For the primary outcome measure of “increasing your interest in a career in toxicology,” the mean was 4.31, with 77% of 2018’s respondents (and 79% of 2017’s respondents) saying the program helped do this “Quite a bit=4” (2 students) or “A great deal=5” (8 students). None of the differences in these outcomes between cohorts was large enough to reach statistical significance.

### Post-program Degree of Interest.

Table 6 shows how students responded to a question about their degree of post-program interests, an indication of the influence the ToxMSDT program had on the 14 respondents in Table 6a (1<sup>st</sup> cohort) and 13 respondents Table 6b (2<sup>nd</sup> cohort). The responses from both cohorts indicate program impact as most students indicated enrolling in additional toxicology-related programs, going to graduate school, or joining professional schools.

### Mentors Expectation Measures.

Mentors from the 1<sup>st</sup> and 2<sup>nd</sup> cohorts responded on a 5-point Likert scale to the question “In your experience, how worthwhile did the following activities turn 1<sup>st</sup> cohort mentors) out to be?” The activities rated most worthwhile are listed first in Table 7a (1 and Table 7b (2<sup>nd</sup> cohort mentors). In Table 7a, the most worthwhile program activities for 2017’s mentors were “Two Days in the Life of a Toxicologist visit” (weight average = 4.86) and 2<sup>nd</sup> cohort), all ten program activities “ISU’s Mentor & Mentee Table Talks” (4.71). In Table 7b (2 that 2018’s mentors were asked about received mean ratings of 4.21 or higher on a 1–5 scale. The highest-rated activities for mentors were “Being part of the program’s community of mentors & mentees” (Mean = 4.92) and the “Two Days in the Life of a Toxicologist visit” (4.86). However, both cohorts rated being paired with their mentee at the SOT conference and communication with their respective mentees between meetings and visit least favorably. None of the differences between cohorts reached statistical significance.

In addition to the program’s activities, there are several key factors in making the program easier for mentors. When asked whether “Over the course of this year, do you feel you received enough information about what was expected of you,” 100% of mentors working with the 2<sup>nd</sup> cohort and 87% working with the 1<sup>st</sup> cohort said, “Yes.”

### Mentors’ Perception of Program Effectiveness and Post-program Engagement.

Structured mentor feedback was gathered through the mentors survey (to which all 15 mentors responded in 2017 and 14 of 15 mentors responded in 2018), and a focus group with mentors at the 2018 Capstone Event (in which all mentors except the program director participated). Seven (30%) acted as mentors for both years/cohorts of the program. The survey used a 5-point Likert scale to determine the perception of the program’s effectiveness and post-program engagement (see Table 8a (1<sup>st</sup> cohort) and Table 8b (2<sup>nd</sup> cohort). Among these four items, the hardest thing to get right for the program was “the match between a mentor’s work and the mentee’s interests”, but even that was rated highly by 10 (67%) of 2017’s 15 respondents and 11 (79%) of 2018’s 14 respondents. Both cohorts of mentors rated their interests to remain engaged in the program the highest, followed by suitability of mentors current work to keep mentees engaged for the two days in the life of a toxicologist event. None of the differences in these outcomes between cohorts reached statistical significance.

Mentors were asked in May of 2017 and 2018 about the post-program activities in which they would be willing to engage, Table 9 shows the activities rated from the most to the least popular. These results show that most mentors are willing to continue to meet with mentees at the SOT conference even if they not mentoring new students, participate in

future ToxMSDT meetings, maintain online contact with their mentees, write letters or recommendation for their mentees and respond to questions from mentees.

Table 9 indicates that the majority of mentors are committed and willing to continue to engage their mentees once they graduate. This is very good news as it indicates that mentors are invested in the program long-term. For example, 100% of mentors for both the first and second cohort would meet with their mentees at future SOT conferences, and 100% of the second cohort mentors would maintain online contact with their mentees and participate in activities at future program meetings. Similarly, 93% of first cohort mentors would engage with their mentees in post-program activities. The lowest percentage of engagement concerned posting updates on the ToxMSDT Facebook page and making a short video about their toxicology job and its appeal. The latter may be due to the fact that video production is usually time-intensive work.

### **Mentors' Suggestions for Improving the Program.**

Mentors in both years (2017 and 2018) were asked to provide feedback on how the ToxMSDT program should be improved. The following is a summary of their recommendations. Overwhelmingly, mentors suggested a need to improve the mentor/mentee match up. Specifically, mentors asked that their input be considered in the matching-up process. During the two-year pilot phase, pairing of mentees with mentors was done by program directors using responses to a survey questionnaire which was completed by the mentees and mentors. Suggestions for improvement in pairing up mentees and mentors include: a) have students and mentors meet before pairing and have each student indicate top three choices, and b) allocate time to mentors to present their work and responsibilities at the inaugural (opening event) such that prospective mentees can use this knowledge in ranking mentors for a match.

Mentors liked the flint lead poisoning real-life toxicology video case presentation. They recommended including more of these real-life toxicology case presentations to catch the attention of students. In addition, mentors also suggested screening for individuals with interest in toxicology. It was pointed out that some of the mentees had not yet made up their minds about their career choices. They also suggested a better communication platform for mentors to interact with their mentees was needed to assure more seamless communications. Finally, another suggestion proposed by mentors was to involve toxicology-focused ToxMSDT alumni in future ToxMSDT program activities such as conducting campus tours, and as guides at conferences such as the annual Society of Toxicology Meeting.

### **Follow-up Survey with Alumni.**

A follow-up survey with ToxMSDT alumni was important for tracking the impact of the program on mentee's post-program engagements and whether they align with toxicology or related fields. Post-program survey questions were; "Are you still enrolled as an undergraduate student," "If graduated, are you currently working or in graduate school," "Where do you see yourself in January 2020," and "What other toxicology related activities have you engaged in since graduating from ToxMSDT"?

Results showed that out of the thirty students who have completed the ToxMSDT program, all 10 (100%) of the program's graduated alumni had enrolled in graduate school in toxicology or other field in an area of NIH interest. Meanwhile, 20 (66.6%) of the mentees are still enrolled as undergraduates, and some have engaged in research activities in the toxicology field or other related areas. Five of those 20 (25%) are in the process of applying/preparing for interviews for graduate programs and medical schools. Table 10 show details of the mentees survey in 2019 about other toxicology-related activities they have engaged in since graduating from ToxMSDT and where they see themselves in January 2020. Nine respondents had participated in additional training in fields related to toxicology. Twelve respondents indicated that in 2020 they planned to pursue graduate training in toxicology or areas of NIH interest.

ToxMSDT program participants, as shown in Table 10, have engaged in a wide range of toxicology-related activities since graduating from the ToxMSDT program. These include enrollment in a summer research programs, enrollment in a toxicology graduate program, and enrollment in medical-related professional programs. Most of these participants also aim at pursuing a masters or PhD in toxicology or related areas or professional degrees. This is a good sign, indicating that the ToxMSDT program had a positive impact on these students.

## Discussion

The ToxMSDT program is a one-year long holistic program dedicated to mentoring and training underrepresented undergraduates in skills needed primarily to become competitive for entry to graduate research in toxicology and, secondarily, other disciplines of NIH interest. This study reported on the outcome of a two-year pilot program built from the ground up (*de novo*). The training program is executed through a combination of online and face-to-face training that introduces toxicology principles and careers and an extensive mentoring program, providing one-to-one interactions of students with mentors who are toxicology professionals. The program prepares talented STEM-focused undergraduates to pursue graduate studies in toxicology and closely aligned disciplines in order to diversify the nation's biomedical fields. A review of the two-year pilot program shows the program's largest (pre-post) impacts on two student cohorts in Table 3. The statistically significant increases indicate mentees' interest in studying toxicology. This confirms that early exposure of undergraduate students to specific research skills may influence their career choice of that field.

This program utilized various activities to train mentees in developing research skills necessary for future career in Toxicology or related fields, as emphasized by the SOT Toxicology Education Summit (Barchowsky et al., 2012). All 15 of the activities listed had a mean rating of at least 3.38 on the 5-point scale, and all but four had means of at least 4.00 ("Quite a bit") as shown in Table 4a (1st cohort) in 2017. Fourteen of the 15 activities received a mean rating of 4.00 or higher as shown in Table 4b (2<sup>nd</sup> cohort) in 2018, with one exemption, attending the *In Vitro* Luncheon at SOT") which received a rating of 3.33, with only 3 students indicating it was beneficial. The reason cited was that the *In Vitro* Luncheon lecture was too advanced and seemed to align more with graduate students than

undergraduate students, as indicated by the mentees at the focus group. This activity will be eliminated in subsequent cohorts, as it is too advanced for the undergraduate students.

It is worth noting that the highest-rated activities from both cohorts (all with means of 4.50 or higher) were those associated with building a community of high-achieving students interested in toxicology, indicating that targeted exercises related to toxicology can enhance learning and development of career interest in toxicology. As interest level for these activities increased, mentees were able to maximize various opportunities for their benefit as shown in Tables 5 and 6. Further analysis of the students' explanatory responses showed that the one-year long holistic program helped the students develop self-confidence by interacting and engaging in intellectual conversations with undergraduates, graduate students, and mentors other than the one assigned to them. Students also developed a sense of belonging by participating in various events like SOT conferences, where they were exposed to creating personal and professional connections in the field of toxicology. They spoke highly of the real-life impact toxicologists have by citing the kickoff event's interactive Flint Michigan lead poisoning Case study. When mentees were asked for the most important thing to change or improve, the most popular response was "more case studies". Therefore, the program directors plan to develop more case studies of human and animal intoxication for use in the training program to drive home student interest in toxicology. These will be based on real field cases for relevance. A thorough search of the literature has found that there is a lack of good quality case studies in video format for use in this course. Thus, they will have to be developed with future funding.

Another important component of the program was the exposure of students to the different toxicology career paths in academia, industry, and the public and private sectors (Ghee, Collins, Wilson, & Pearson, 2014). This was done by matching underrepresented minority mentees to a committed cadre of toxicology mentors drawn from broad backgrounds in industry, government and academia (Table 1). Mentors from industry were particularly important, as they demonstrated that there is life for a toxicologist outside of a laboratory or academics. We purposely recruited mentors from industry and government because these two sectors employ the majority of toxicologists.

Among the list of program activities surveyed to measure mentors' expectations (Table 7a), the most highly-rated program activities for 2017's mentors were "Two Days in the Life of a Toxicologist visit" and "ISU's Mentor & Mentee Table Talks". In Table 7b, the most highly-rated program activities were "Being part of the program's community of mentors & mentees" and the "Two Days in the Life of a Toxicologist visit". This is notable considering students spent only two days visiting their mentors at their places of work. Future evaluations will query mentees and mentors independently to see if we can maximize the benefit of this part of the training programs. This is an aspect of the ToxMSDT training program shared by no other toxicology training program.

Mentors' engagement in post-program activities makes ToxMSDT a unique program, as the mentorship benefit is extended beyond one year (again see Table 9). Mentors expressed their willingness to maintain contact with their mentees as they navigate through their career path in toxicology and to write recommendation letters for ToxMSDT alumni. The evaluation

included a follow-up survey of the ToxMSDT alumni to keep record of their interest levels in toxicology and future plans. Results (Table 10) revealed a significant positive effect on mentees' post-program activities, mostly engaging in further undergraduate research programs and maintaining a focus in toxicology. These results indicate that a bond was created between mentors and mentees, which grew and extended beyond the required one-year time period of the program. Future surveys will evaluate mentor-mentee contact several years after the program has ended.

Mentors also gave excellent feedback regarding challenges they encountered with the program and with their mentees. They volunteered suggestions about improving the program, including the process of pairing up mentees with mentors. For this pilot phase, pairing of mentees with mentors was done by program directors using responses to a survey that was completed by the mentees and the mentors. The program director's used their judgment to match mentees to mentors, largely based on expressed future career interests of the mentee. It is clear from the feedback that this approach did not work well. Going forward, mentors will be invited to provide input in matching up with mentees in addition to information gleaned from the surveys. Better mentee/mentor pairing should result in more satisfaction and better program outcomes. Consistent with the mentoring framework for ToxMSDT (Agholor et al., 2017; Young & Perrewé, 2000), mentee choices will be given paramount consideration.

Mentors and mentees alike recommended including more of real-life toxicology case presentations to catch the attention of students. Whereas this suggestion is excellent, unfortunately there is a lack of quality objective toxicology case studies on video for teaching purposes. However, ToxMSDT program directors have applied for funds to develop new toxicology case-studies to be used for training future cohorts. These videos will be made available online and accessible to the general public for teaching and outreach.

Additional suggestions from mentors focused on better selection of mentees with interest in toxicology and providing a better communication platform for mentors to interact with their mentees. This shortcoming of the pilot phase of ToxMSDT will be eliminated as we move beyond recruitment from two institutions, Iowa State University and Tuskegee University, which had a limited pool of students. We plan to expand the ToxMSDT program into a nation-wide program limited to 20–30 slots of students. This will likely make it a highly competitive national program and lead to the selection of students with an expressed interest in toxicology. The program will also seek access to nationwide mentoring technology platforms to improve mentee-mentor collaboration. Also, program directors will require mentees to work with their mentors on the capstone project to provide more opportunities for mentee-mentor interaction. Collectively, these changes will increase the quality of students, lead to admission of students largely with interest in toxicology, and help improve communication between mentees and mentors.

Finally, it was proposed by mentors to involve toxicology-focused ToxMSDT alumni in future ToxMSDT activities such as conducting campus tours, and as guides at conferences like the annual Society of Toxicology Meeting. This is consistent with feedback indicating that students enjoyed interacting with peers at the SOT conference. Going forward,

ToxMSDT plans to expose mentees to students currently enrolled in toxicology graduate programs during the kickoff event and at the annual SOT meetings. The program will explore recruiting toxicology graduate students as guides at face-to-face meetings.

## Limitations

This ToxMSDT program has strategically targeted undergraduate students. It will take years before we know how many of these ToxMSDT sophomores, juniors, and seniors will enter the toxicology pipeline and graduate with degrees and/or are employed in toxicology or pursue a related career. Therefore, the major limitation of this study is that it is still in the early stages with modest data that inhibit our drawing definitive conclusions about the success of the program, beyond our currently promising findings. Whatever future statistics may reveal, one of the outcomes of this novel toxicology pipeline program is that graduates of ToxMSDT have been exposed to toxicology and they will always be toxicologically aware in whatever careers they choose. One challenge already encountered, in tracking program outcomes once students have graduated, is loss of student contact. One of the roles of the ToxMSDT program coordinator must be to track graduates and mentors through the ToxMSDT community website, social media and outreach to alumni.

## Conclusion

This two-year proof-of-concept program, which was built from the ground up, has already had a direct impact on the career choice of many of the undergraduate participants. Online learning modules have been developed and are publicly available 24/7 on mobile devices and computers with an internet connection. Results of program evaluations are very encouraging. The program has clearly increased students' awareness of toxicology as a profession. The program has recruited a devoted cadre of mentors who have indicated a willingness to continue taking on new mentees and engaging alumni many years after students have graduated. This long-term contact is essential for the success of the program. Collectively, these efforts will increase the likelihood of retaining budding toxicologists in the profession. Currently, out of thirty students who have completed the ToxMSDT program, all 10 (100%) of our graduated mentees have enrolled in toxicology-related graduate training programs, including: Toxicology, Pharmacology, Molecular and Systems Pharmacology, Biochemistry and Molecular Biology, Chemistry Ph.D. programs, NIH-Post-baccalaureate Research Education Program (PREP), Master of Agricultural and Environmental education, Master's program in Nutrition, Dental and Pharmacy schools.

Meanwhile 20 (66.6%) of the ToxMSDT alumni are still enrolled as undergraduates, and some have engaged in further undergraduate research activities in US Department of Agriculture forest service, Maximizing Access to Research Careers (MARC) Undergraduate Student Training in Academic Research (U\*STAR) fellowship program, SURE Tox, ecotoxicity, nanotoxicity, oxidative distress, bioinorganic chemistry, ecology class featuring ecotoxicity, written research paper featuring toxicology literature etc., with five of those 20 (25%) in the process of applying/preparing for interviews for graduate programs and medical schools. A future plan is to expand enrollment and open the program nationally to all underrepresented communities in the US.

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**Table 1.**

## Mentor Demographics

| Variables                     | N  |
|-------------------------------|----|
| <b>N Race/ethnicity</b>       |    |
| African-Americans             | 9  |
| Asians                        | 7  |
| Hispanics                     | 2  |
| Caucasians                    | 4  |
| <b>Employer</b>               |    |
| Academia                      | 4  |
| Federal/State                 | 5  |
| Government Industry           | 12 |
| Independent consultant        | 1  |
| Non-Governmental Organization | 1  |
| <b>Gender</b>                 |    |
| Females                       | 10 |
| Males                         | 13 |

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**Table 2.**

## Mentee Demographics

| Variables                             | N  |
|---------------------------------------|----|
| <b>Race/ethnicity</b>                 | 21 |
| African-Americans                     | 7  |
| Hispanic Asian                        | 2  |
| <b>STEM majors</b>                    |    |
| Animal Science/Animal Health          | 4  |
| Biology or Biochemistry               | 11 |
| Chemistry and/or Chemical Engineering | 10 |
| Ecological or Environmental Science   | 2  |
| Kinesiology & Health                  | 1  |
| Microbiology                          | 1  |
| Nutrition & Food Science              | 1  |
| <b>Undergraduate level</b>            |    |
| Sophomores                            | 11 |
| Juniors                               | 10 |
| Seniors                               | 9  |
| <b>Gender</b>                         |    |
| Females                               | 23 |
| Males                                 | 7  |
| <b>Home Universities</b>              |    |
| Tuskegee University                   | 15 |
| Iowa State University                 | 11 |
| Florida International University      | 1  |
| Georgia Southern University Agnes     | 1  |
| Scott College                         | 1  |

**Table 3a.**

1<sup>st</sup> Cohort Response to Program Outcomes

| Now that you have completed this, program, how much...                        | Not at all/ None = 1 | Very Little = 2 | Some = 3 | Quite a bit = 4 | A great Deal =5 | Mean Before (SD) | Mean After (SD) | Mean Change (SD)    |
|---|----------------------|-----------------|----------|-----------------|-----------------|------------------|-----------------|---------------------|
| have you interacted with people in toxicology?                                | 0.0%                 | 7.1%            | 14.3%    | 35.7%           | 42.9%           | 1.29 (0.47)      | 4.14 (0.95)     | <b>2.86* (1.17)</b> |
| knowledge do you have about a career in toxicology?                           | 0.0%                 | 0.0%            | 0.0%     | 64.3%           | 35.7%           | 2.00 (1.18)      | 4.36 (0.50)     | <b>2.36* (1.45)</b> |
| do you feel a part of the toxicology community?                               | 0.0%                 | 0.0%            | 28.6%    | 50.0%           | 21.4%           | 1.64 (1.15)      | 3.93 (0.73)     | <b>2.29* (1.14)</b> |
| do you see yourself as someone who will study toxicology?                     | 7.1%                 | 7.1%            | 21.4%    | 35.7%           | 28.6%           | 2.43 (1.34)      | 3.71 (1.20)     | <b>1.29* (1.44)</b> |
| interest do you have in a biomedical, behavioral or clinical research career? | 0.0%                 | 7.1%            | 21.4%    | 35.7%           | 35.7%           | 3.71 (1.27)      | 4.00 (0.96)     | <b>0.29 (1.14)</b>  |
| do you see yourself getting a post-graduate degree (MS, PhD, MD)?             | 0.0%                 | 7.1%            | 0.0%     | 14.3%           | 78.6%           | 4.50 (0.65)      | 4.64 (0.84)     | <b>0.14 (0.53)</b>  |

\* =statistically significant increases at  $p < .01$

\*\* How 14 Mentees from the 1<sup>st</sup> cohort responded on a 5-point scale regarding main program outcomes, with % showing responses after the program, followed by group means before the program, after the program, and the mean change

**Table 3b.**2<sup>nd</sup> Cohort Response to Program Outcomes

| Now that you have completed this, program, how much...                        | Not at all/None = 1 | Very Little = 2 | Some = 3 | Quite a Bit = 4 | A Great Deal =5 | Mean Before (SD) | Mean After (SD) | Mean Change (SD)    |
|---|---------------------|-----------------|----------|-----------------|-----------------|------------------|-----------------|---------------------|
| have you interacted with people in toxicology?                                | 0.0%                | 0.0%            | 15.4%    | 38.5%           | 46.2%           | 1.77 (0.73)      | 4.31 (0.75)     | <b>2.54* (0.97)</b> |
| knowledge do you have about a career in toxicology?                           | 0.0%                | 7.7%            | 15.4%    | 53.8%           | 23.1%           | 1.62 (1.04)      | 3.93 (0.86)     | <b>2.31* (1.60)</b> |
| do you feel a part of the toxicology community?                               | 0.0%                | 0.0%            | 30.8%    | 38.5%           | 30.8%           | 1.85 (0.90)      | 4.00 (0.82)     | <b>2.15* (1.14)</b> |
| do you see yourself as someone who will study toxicology?                     | 7.7%                | 7.7%            | 23.1%    | 38.5%           | 30.8%           | 2.54 (1.05)      | 3.92 (0.95)     | <b>1.38* (1.33)</b> |
| interest do you have in a biomedical, behavioral or clinical research career? | 0.0%                | 15.4%           | 15.4%    | 30.8%           | 38.5%           | 3.77 (1.09)      | 3.92 (1.12)     | <b>0.15 (1.07)</b>  |
| do you see yourself getting a post-graduate degree (MS, PhD, MD)?             | 0.0%                | 7.7%            | 7.7%     | 7.7%            | 76.9%           | 4.38 (0.87)      | 4.54 (0.97)     | <b>0.15 (0.99)</b>  |

\* =statistically significant increases at  $p < 0.012$

**Table 4a.**1<sup>st</sup> Cohort Rating of Program Main Activities

| How much did you get out of the following program activities?               | Not at all/<br>None = 1 | Very<br>Little = 2 | Some = 3 | Quite a bit<br>= 4 | A great<br>deal = 5 | N  | Mean (SD)   |
|---|-------------------------|--------------------|----------|--------------------|---------------------|----|-------------|
| Visiting the other university associated with this program                  | 0.0%                    | 0.0%               | 0.0%     | 14.3%              | 85.7%               | 14 | 4.86 (0.36) |
| Hearing other students' presentations at Tuskegee's Capstone event          | 0.0%                    | 0.0%               | 7.1%     | 14.3%              | 78.6%               | 14 | 4.71 (0.61) |
| Attending SOT's Undergraduate Day   | 0.0%                    | 0.0%               | 7.1%     | 28.6%              | 64.3%               | 14 | 4.57 (0.65) |
| Time with other students interested in Toxicology at the SOT Conference.    | 0.0%                    | 0.0%               | 14.3%    | 21.4%              | 64.3%               | 14 | 4.50 (0.76) |
| Viewing the two required online modules associated with the ToxMSDT program | 0.0%                    | 0.0%               | 14.3%    | 28.6%              | 57.1%               | 14 | 4.43 (0.76) |
| 2 Days in the Life of a Toxicologist visit                                  | 14.3%                   | 0.0%               | 0.0%     | 14.3%              | 71.4%               | 7  | 4.29 (1.50) |
| Preparing and doing a presentation at Tuskegee's Capstone event             | 0.0%                    | 0.0%               | 7.1%     | 50.0%              | 42.9%               | 14 | 4.36 (0.63) |
| Visiting ISU's Vet Med Labs   | 0.0%                    | 0.0%               | 28.6%    | 28.6%              | 42.9%               | 14 | 4.14 (0.86) |
| Completing CITI's "Responsible Conduct of Research Training"                | 0.0%                    | 7.1%               | 14.3%    | 35.7%              | 42.9%               | 14 | 4.14 (0.95) |
| Viewing additional/optional toxicology modules on the ToxMSDT website       | 0.0%                    | 0.0%               | 25.0%    | 37.5%              | 37.5%               | 8  | 4.13 (0.83) |
| Contacts with my mentor between program events                              | 14.3%                   | 0.0%               | 7.1%     | 28.6%              | 50.0%               | 14 | 4.00 (1.41) |
| Attending SOT's In Vitro lunch lecture                                      | 0.0%                    | 7.1%               | 21.4%    | 42.9%              | 28.6%               | 14 | 3.93 (0.92) |
| ISU's Mentor & Mentee Table Talks   | 0.0%                    | 0.0%               | 35.7%    | 42.9%              | 21.4%               | 14 | 3.86 (0.77) |
| Seeing posters & presentations at the SOT Conference                        | 0.0%                    | 7.1%               | 28.6%    | 42.9%              | 21.4%               | 14 | 3.79 (0.89) |
| Being paired with mentor for a day at the SOT Conference                    | 0.0%                    | 38.5%              | 15.4%    | 15.4%              | 30.8%               | 13 | 3.38 (1.33) |

**Table 4b.**2<sup>nd</sup> Cohort Rating of Program Main Activities

| How much did you get out of the following program activities?                | Not at all/<br>None = 1 | Very little<br>= 2 | Some = 3 | Quite a bit<br>= 4 | A great<br>deal = 5 | N  | Mean (SD)   |
|--|-------------------------|--------------------|----------|--------------------|---------------------|----|-------------|
| 2 Days in the Life of a Toxicologist visit.                                  | 0.0%                    | 0.0%               | 0.0%     | 15.4%              | 84.6%               | 13 | 4.85 (0.38) |
| Time with other students interested in toxicology at the SOT Conference.     | 0.0%                    | 0.0%               | 0.0%     | 30.8%              | 69.2%               | 13 | 4.69 (0.48) |
| Visiting the other university associated with this program.                  | 0.0%                    | 0.0%               | 8.3%     | 16.7%              | 75.0%               | 12 | 4.67 (0.65) |
| Viewing the two required online modules associated with the ToxMSDT program. | 0.0%                    | 0.0%               | 7.7%     | 15.4%              | 69.2%               | 12 | 4.67 (0.65) |
| Viewing additional/optional toxicology modules on the ToxMSDT website.       | 0.0%                    | 0.0%               | 7.7%     | 23.1%              | 69.2%               | 13 | 4.62 (0.65) |
| Dr. Rumbeiha & Dr. Wolf's presentation at the Capstone Event.                | 0.0%                    | 0.0%               | 8.3%     | 50.0%              | 41.7%               | 12 | 4.43 (0.65) |
| Hearing other students' presentations at Tuskegee's Capstone event.          | 0.0%                    | 0.0%               | 16.7%    | 25.0%              | 58.3%               | 12 | 4.42 (0.79) |
| Attending SOT's Undergraduate Day.   | 7.7%                    | 0.0%               | 0.0%     | 30.8%              | 61.5%               | 13 | 4.38 (1.12) |
| Preparing and doing a presentation at Tuskegee's Capstone event.             | 0.0%                    | 0.0%               | 15.4%    | 38.5%              | 46.2%               | 13 | 4.31 (0.75) |
| Contacts with my mentor between program events.                              | 0.0%                    | 0.0%               | 23.1%    | 23.1%              | 53.8%               | 13 | 4.31 (0.85) |
| Spending time with a mentor during SOT.                                      | 0.0%                    | 7.7%               | 23.1%    | 15.4%              | 53.8%               | 13 | 4.15 (1.07) |
| Seeing posters & presentations at the SOT Conference.                        | 0.0%                    | 0.0%               | 23.1 %   | 46.2%              | 30.8%               | 13 | 4.08 (0.76) |
| Attending SOT's In Vitro lunch lecture.                                      | 0.0%                    | 16.7%              | 58.3 %   | 0.0%               | 25.0%               | 12 | 3.33 (1.07) |

**Table 5a.**

## 1st Cohort Response to Program Benefits

| How much has this program helped you to do the following?                       | Not at all / None = 1 | Very little = 2 | Some = 3 | Quite a bit = 4 | A great Deal = 5 | Mean (SD)   |
|---|-----------------------|-----------------|----------|-----------------|------------------|-------------|
| understand what a career in toxicology involves                                 | 0.0%                  | 0.0%            | 7.1%     | 7.1%            | 85.7%            | 4.79 (0.58) |
| form connections with other students interested in toxicology                   | 0.0%                  | 0.0%            | 7.1%     | 7.1%            | 85.7%            | 4.79 (0.58) |
| increase your skill and confidence interacting with toxicology researchers      | 0.0%                  | 0.0%            | 14.3%    | 28.6%           | 57.1%            | 4.43 (0.76) |
| learn about or meet toxicologists you can relate to                             | 0.0%                  | 7.1%            | 21.4%    | 0.0%            | 71.4%            | 4.36 (1.08) |
| form a connection with your mentor for this program                             | 7.1%                  | 7.1%            | 14.3%    | 7.1%            | 64.3%            | 4.14 (1.35) |
| increase your interest in a biomedical, behavioral, or clinical research career | 0.0%                  | 7.1%            | 14.3%    | 35.7%           | 42.9%            | 4.14 (0.95) |
| increase your interest in a career in toxicology                                | 0.0%                  | 7.1%            | 14.3%    | 35.7%           | 42.9%            | 4.14 (0.95) |
| feel like a part of the toxicology community                                    | 0.0%                  | 0.0%            | 28.6%    | 35.7%           | 35.7%            | 4.07 (0.83) |
| see yourself as someone who will study toxicology                               | 7.1%                  | 7.1%            | 7.1%     | 35.7%           | 42.9%            | 4.00 (1.24) |

**Table 5b.**

## 2nd Cohort Response to Program Benefits

| How much has this program helped you to do the following?                        | Not at all / None = 1 | Very little = 2 | Some = 3 | Quite a bit = 4 | A great deal = 5 | Mean (SD)   |
|--|-----------------------|-----------------|----------|-----------------|------------------|-------------|
| learn about or meet toxicologists you can relate to.                             | 0.0%                  | 0.0%            | 0.0%     | 15.4%           | 84.6%            | 4.85 (0.38) |
| understand what a career in toxicology involves.                                 | 0.0%                  | 0.0%            | 0.0%     | 23.1%           | 76.9%            | 4.77 (0.44) |
| form connections with other students interested in toxicology.                   | 0.0%                  | 0.0%            | 7.7%     | 30.8%           | 61.5%            | 4.54 (0.66) |
| increase your skill and confidence interacting with toxicology researchers.      | 0.0%                  | 0.0%            | 0.0%     | 61.5%           | 38.5%            | 4.38 (0.51) |
| increase your interest in a biomedical, behavioral, or clinical research career. | 0.0%                  | 7.7%            | 7.7%     | 23.1%           | 61.5%            | 4.38 (0.96) |
| feel like a part of the toxicology community.                                    | 0.0%                  | 0.0%            | 15.4%    | 30.8%           | 53.8%            | 4.38 (0.77) |
| see yourself as someone who will study toxicology                                | 0.0%                  | 7.7%            | 7.7%     | 23.1%           | 61.5%            | 4.38 (0.96) |
| increase your interest in a career in toxicology.                                | 0.0%                  | 7.7%            | 15.4%    | 15.4%           | 61.5%            | 4.31 (1.03) |
| form a connection with your mentor for this program.                             | 0.0%                  | 0.0%            | 30.8%    | 15.4%           | 53.8%            | 4.23 (0.93) |



**Table 6a.**

## 1st Cohort Post-program Degree of Interest in Toxicology

| Interest Level | Describe what, if anything, you plan to do in the year ahead (including this summer) to get more involved in toxicology.   |
|----------------|--|
| 10             | This summer I have an internship with SURETox at University of Illinois. I will also be looking into graduate schools with great toxicology programs during the summer. and applying to them in the fall. I also hope to attend SOT next year and maybe get the opportunity to visit some of the graduate schools.   |
| 9              | SureTox internship   |
| 9              | Research or lab position   |
| 8              | Internship with SURETox  |
| 8              | N/A [respondent is a sophomore]  |
| 7              | This summer, I have an internship with ISU Extension where I will be working to improve and expand regional food systems. Now knowing that toxicology impacts all things, I will remember all I have learned through this program when completing this internship. I will be working closely with food growers and I hope to ask questions regarding toxicology and how it affects their daily lives as farmers. I plan to look more into graduate schools that offer toxicology programs because the more I learn about toxicology, the more interested I become. |
| 7              | I'd certainly like to stay in touch with my mentor as well as some of the other mentors that participated in this program. For example, two of the mentors expressed great interest in helping me apply for toxicology internships at their worksites, so I plan on applying for these when the time comes.  |
| 7              | I have become heavily interested in chemical toxicology after learning of Dr. Rumbeiha's research and attending certain presentations at SOT. I'm going to definitely keep this as an option when looking into graduate programs or even in establishing my career.  |
| 7              | I plan to do research on vaccines and the effect of exercise in preventing disease. As of right now, I want to enter a MD/PhD program. Over this summer I will be studying at the University of Columbia.  |
| 7              | Within the next year, I hope to learn about more graduate programs that have toxicology and also find summer programs that will give me more hands-on exposure to the field.   |
| 7              | I will enter into a PhD program [IUSM's in Biomedical Sciences] and do a rotation in Toxicology.   |
| 6              | I plan on volunteering abroad for a gap year and afterward get a lab technician position. Then go to graduate school.  |
| 5              | I'm not interested in getting more involved in toxicology, but I do hope to continue using online modules to increase my awareness.  |
| 4              | I still need to have my toxicologist shadow experience, so I will be doing that in May. I might look into a graduate program at Tuskegee -probably not in toxicology though.   |

**Table 6b.**2<sup>nd</sup> Cohort Post-program Degree of Interest in Toxicology

| Interest Level | Describe what, if anything, you plan to do in the year ahead (including this summer) to get more involved in toxicology.   |
|----------------|--|
| 10             | This summer, I will be at the University of Illinois Urbana-Champaign where I will work on a research project that is related to the field of toxicology.  |
| 9              | This summer I will be participating in a summer research program at the University of Minnesota (LSSURP). In this program, I will be conducting research on colon cancer. Although this is not strictly toxicology, I can apply toxicological concepts into this area of research. I plan on pursuing a PhD with a focus in Toxicology in the future.  |
| 9              | I will be in the ISU Tox PhD program in fall 2018.   |
| 8              | This summer I am completing an internship as a biological technician with the National Park Service at Isle Royale. After the completion of this project I plan on securing a fall internship and attending graduate school in the spring where I can pursue a major that combines wildlife conservation and environmental Science with toxicology.  |
| 8              | Now that the field of Toxicology is on my radar, I am researching about possible graduate studies in the field of Toxicology.  |
| 8              | For this summer I will working with EOP (Early Outreach Program), which is a program where high school students that are identified as a minorities, come to the Iowa State campus for a week. At this program I will like to share my Story to the students and mention to them, the opportunities out there. Adding to that I will be also doing research that has to do with glycemic responds with beans. I see myself going into pharmacy, working in an emergency room, with the background of toxicology. |
| 7              | Do research and reach out to toxicologists at the university to see if I can broaden my perspectives on toxicology. Apply to graduate school with the possibility of focusing on toxicology.   |
| 7              | Continue to talk with my mentor from the program, participate in a summer research program to further identify my research interests, and hopefully attend SOT or the SESOT conference.  |
| 7              | I will bring a toxicology mind to my internship this summer.   |
| 7              | I am interning as a missionary and will be teaching kids about animals. I work in environmental science. I want to visit schools in California, Florida, North Carolina and more. I am thinking about the toxicology route in grad school. I'll be attending a Costa Rica conference, with many more to come.  |
| 6              | Job shadowing.   |
| 6              | Currently, I am performing research at the Pacific Northwest National Lab as a GEM fellow and in the fall I will begin grad school (Ph.D.) at the University of Missouri-Columbia.   |
| 3              | I plan to keep in contact with my mentor during the year ahead, and exploring areas of holistic wellness in people.  |

**Table 7a.**Mentors' Expectations from the 1<sup>st</sup> Cohort

| In your experience, how worthwhile did the following activities turn out to be? | Not at all = 1 | 2     | 3     | 4     | Very= 5 | N  | Mean (SD)   |
|---|----------------|-------|-------|-------|---------|----|-------------|
| Two Days in the Life of a Toxicologist Visit                                    | 0.0%           | 0.0%  | 0.0%  | 14.3% | 85.7%   | 14 | 4.86 (0.36) |
| ISU's Mentor & Mentee Table Talks.  | 0.0%           | 0.0%  | 7.1%  | 14.3% | 78.6%   | 14 | 4.71 (0.61) |
| Mentor/mentee communications between meetings & visits.                         | 0.0%           | 13.3% | 20.0% | 20.0% | 46.7%   | 15 | 4.00 (1.13) |
| Being paired with my mentee for 2 days at SOT Conference.                       | 0.0%           | 21.4% | 21.4% | 14.3% | 42.9%   | 14 | 3.79 (1.25) |

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**Table 7b.**Mentors' Expectations from the 2<sup>nd</sup> Cohort

| In your experience, how worthwhile did the following activities turn out to be? | Not at all= 1 | 2    | 3     | 4     | Very = 5 | N  | Mean (SD)   |
|---|---------------|------|-------|-------|----------|----|-------------|
| Being part of the program's community of mentors & mentees.                     | 0.0%          | 0.0% | 0.0%  | 14.3% | 92.3%    | 13 | 4.92 (0.28) |
| Two Days in the Life of a Toxicologist Visit.                                   | 0.0%          | 0.0% | 0.0%  | 14.3% | 85.7%    | 14 | 4.86 (0.36) |
| Sessions with Mentees at ISU's Kickoff Meeting.                                 | 0.0%          | 0.0% | 0.0%  | 25.0% | 75.0%    | 12 | 4.75 (0.45) |
| SOT Undergraduate Program's Career Roundtables.                                 | 0.0%          | 0.0% | 0.0%  | 28.6% | 71.4%    | 7  | 4.71 (0.49) |
| Seeing student presentations at Tuskegee's Capstone Event.                      | 0.0%          | 0.0% | 7.7%  | 15.4% | 76.9%    | 13 | 4.69 (0.63) |
| Leadership & Mentoring training you received at the Kickoff Meeting.            | 0.0%          | 0.0% | 16.7% | 25.0% | 58.3%    | 12 | 4.42 (0.79) |
| SOT Undergraduate Program's session on how to mentor graduate students.         | 0.0%          | 0.0% | 25.0% | 12.5% | 62.5%    | 8  | 4.38 (0.92) |
| Communications with your mentee between meetings & visits.                      | 0.0%          | 7.1% | 14.3% | 14.3% | 64.3%    | 14 | 4.36 (1.01) |
| Interactions with other's mentees during The SOT Conference.                    | 0.0%          | 7.1% | 0.0%  | 46.2% | 46.2%    | 13 | 4.31 (0.85) |
| Interactions with your mentee during the SOT Conference.                        | 0.0%          | 7.1% | 7.1%  | 42.9% | 42.9%    | 14 | 4.21 (0.89) |

**Table 8a.**1<sup>st</sup> Cohort Mentor Perception of Program Effectiveness and Post-program Engagement

| Based on your experiences this year, please rate the following:                           | Low = 1 | 2    | 3     | 4     | High = 5 | Mean (SD)   |
|---|---------|------|-------|-------|----------|-------------|
| Your interest in remaining engaged with the Program and its mentees next year.            | 6.7%    | 0.0% | 0.0%  | 33.3% | 60.0%    | 4.40 (1.06) |
| The suitability of your current work situation for keeping a mentee engaged for two days. | 6.7%    | 0.0% | 0.0%  | 40.0% | 53.3%    | 4.33 (1.05) |
| The match between you and your mentee's interactional styles.                             | 6.7%    | 0.0% | 26.7% | 20.0% | 46.7%    | 4.00 (1.20) |
| The match between your work and your mentee's interests.                                  | 0.0%    | 6.7% | 33.3% | 20.0% | 40.0%    | 3.93 (1.03) |

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**Table 8b.**

## 2nd Cohort Mentor Perception of Program Effectiveness and Post-program Engagement

| <b>Based on your experiences this year, please rate the following:</b>                    | <b>Low = 1</b> | <b>2</b> | <b>3</b> | <b>4</b> | <b>High = 5</b> | <b>Mean (SD)</b> |
|---|----------------|----------|----------|----------|-----------------|------------------|
| Your interest in remaining engaged with the Program and its mentees next year.            | 0.0%           | 0.0%     | 0.0%     | 14.3%    | 85.7%           | 4.86 (0.51)      |
| The suitability of your current work situation for Keeping a mentee engaged for two days. | 7.1%           | 0.0%     | 7.1%     | 21.4%    | 64.3%           | 4.36 (1.15)      |
| The match between you and your mentee's interactional styles.                             | 0.0%           | 0.0%     | 21.4%    | 28.6%    | 50.0%           | 4.29 (0.83)      |
| The match between your work and your mentee's interests.                                  | 7.1%           | 7.1%     | 7.1%     | 50.0%    | 28.6%           | 3.86 (1.17)      |

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**Table 9.**

Percentage of Mentors from the 1<sup>st</sup> and 2<sup>nd</sup> Cohorts Who Would be Willing to Engage in Various Post-program Activities

| 2017 (n=15) | 2018 (n=14) | Post-program activity in which mentor would be willing to engage                      |
|-------------|-------------|---|
| 100%        | 100%        | Meeting with mentees at the SOT conference even if you aren't mentoring a new student |
| 93.3%       | 100%        | Participating in activities at future ToxMSDT meetings                                |
| 93.3%       | 100%        | Maintaining online contact with your mentee   |
| 80.0%       | 92.9%       | Writing recommendations for your ToxMSDT mentee                                       |
| 100%        | 71.4%       | Responding to questions or article requests from other mentees                        |
| 80.0%       | 85.7%       | Mentoring a new ToxMSDT student in addition to the one you have                       |
| 60.0%       | 71.4%       | Bringing a ToxMSDT mentee to your site for a research project, program or internship  |
| 53.3%       | 50.0%       | Joining/remaining on the ToxMSDT Facebook page  |
| 40.0%       | 35.7%       | Posting updates/news to the ToxMSDT Facebook page                                     |
| 40.0%       | 35.7%       | Making a short video (with assistance) about your toxicology job and its appeal       |

**Table 10.**

## Follow-up Survey with Alumni Mentees, with Explanatory Responses

| What other toxicology related activities have you engaged in since graduating from ToxMSDT?   | Where do you see yourself in 2020?  |
|---|---|
| I worked with a professor doing research in parasitology which involved testing the cytotoxicity of compounds we extracted on cells as well as its effect on the parasite we were studying.   | I am a PhD candidate and focusing on thesis project.  |
| I took ecology class that touched on ecotoxicity and a brain and behavior class that also used some terms that I learned at the ToxMSDT program. Since I had already learned some of the concepts, it was relatively easier for me. | I will be a student in the Emory University Molecular and Systems Pharmacology PhD program.   |
| I participated in The Summer Undergraduate Research Experience in Toxicology (SURE Tox) program, a Toxicology focused Research Experience for Undergraduates (REU) at the University of Illinois at Urbana-Champaign (Summer 2018). | I will be at the Tuskegee University, senior year, preparing to go to medical school, graduate school, or industry.   |
| I worked at an internship at the University of Illinois at Urbana-Champaign and it was a toxicology research. Also, I have applied for graduate programs in pharmacology/toxicology and I have been accepted.                       | I will be a graduating senior and waiting for response from PhD program. In addition, I will be in the process of writing an undergraduate thesis.            |
| I am currently working 20hrs a week in the oxidative stress group at Florida International University where toxicology research overlaps with oxidative distress.   | I will be working at a laboratory and waiting for a response to my applications to graduate school.   |
| I went to another conference that has to do with public health in Boston. I am taking toxicology courses at Iowa State University and at study abroad.  | I will be in Dental College of Georgia D.M.D program.   |
| I worked on Nanotoxicity evaluation of doped Silicon Nanocrystals in model organism, <i>Shewanella Oneidensis</i> , MR-1 at University of Minnesota, summer 2017.   | I will be enrolled in an NIH PREP program conducting research and hopefully preparing to or going on graduate school interviews.                              |
| I took a bioinorganic chemistry course that featured discussions of toxicology. In this course, I wrote a research paper featuring toxicology literature.   | I will be in University of Georgia, in the Masters of Agricultural and Environmental Education program.   |
| I am in Toxicology graduate program.  | I am still in graduate school, working on my Toxicology PhD.  |
|   | I will be in 2nd year of Pharmacy school.   |
|   | I am getting a Ph.D. in Biochemistry and Molecular Biology. Indiana University School of Medicine.  |
|   | I will be Pursuing a PhD in chemistry. Sub-discipline – organic at the University of Southern Mississippi, in the school of mathematics and natural sciences. |