A Collaborative Model to Standardize Forensic DNA Education and Training in the Academic and Professional Environment

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Abstract: Forensic Science Education Programs Accreditation Commission (FEPAC) is an organization that seeks to highlight and enhance the quality of forensic science education at colleges and universities; many graduates of FEPAC-accredited programs are hired by crime laboratory forensic science service providers (FSSPs). Standards collaboratively written by academics and professionals in the forensic science field and published by standards development organizations (SDOs) seek to enhance the quality of the work product by FSSPs. Many of these standards are listed on the National Institute of Standards and Technology (NIST) Organization of Scientific Area Committees (OSAC) Forensic Science Registry. The OSAC Registry is a repository of selected proposed and published standards which the forensic science community is encouraged to implement to advance and standardize the forensic science practice. The Academy Standards Board's (ASB) DNA training standards have standardized concepts and topics, but not the actual curriculum. Following discussions with NIST staff and laboratory directors about this gap, funding was received from the NIST Measurement Science and Engineering Grant Program to develop a curriculum for one standard: ANSI/ASB Standard 115, *Standard for Training in Forensic Short Tandem Repeat Typing Methods using Amplification, DNA Separation, and Allele Detection*. Herein the process and goals and a collaborative model of the approach are described including assembling and working with an external advisory board, surveying and interviewing laboratory directors and their designees on their forensic DNA training programs, development of a standardized forensic DNA curriculum and assessment tool, and dissemination of the deliverables. The collaborative model could be replicated and implemented in other disciplines including forensic toxicology, forensic anthropology, and pattern analysis.

Keywords: Forensic science, training, collaboration, education, standards, forensic DNA, assessment

Introduction

Onboarding and in-house training are important and challenging tasks. There were 423 publicly funded forensic crime laboratories in the United States in 2020 as reported by the Bureau of Justice Programs (1) and more than 18,000 local police departments in the country (2). Dozens of new forensic scientists are hired each year and must be trained to departmental and agency policy and standards.

Scientists collect, screen, sample, and analyze evidence from crime scenes at forensic science service provider (FSSP) laboratories. The scientists employed by the laboratories are educated at one of the hundreds of colleges and universities in operation worldwide earning degrees in fields such as genetics, molecular biology, biochemistry, biology, chemistry, physics, mathematics, criminal justice, anthropology, pathology, and forensic science. These majors require coursework in history, science, mathematics, statistics, writing, ethics, and law. The coursework provides graduates with a breadth of knowledge and a strong theoretical background in their chosen specializations. Programs and majors vary in required coursework, emphasis, faculty specialty, equipment and instrumentation, and space.

Professional and law enforcement agencies differ in their definitions of the term "forensic". As written in a 2004 report, the Technical Working Group on Education and Training in Forensic Science (TWGED) was established to "serve as a reference on best education and training practices for students pursuing careers in forensic science" (3). The Forensic Science Education Programs Accreditation Commission (FEPAC), an accrediting body of the American Academy of Forensic Sciences (AAFS) composed of academics and forensic practitioners, accredited its first program in 2004 (4) and seeks to highlight quality forensic science programs offered by colleges and universities in the United States and Canada

and enhance the quality of forensic science education. "Addressing Shortfalls in Forensic Science Education" was published by the National Institute of Justice (NIJ) in 2007 (5). FEPAC guidelines describe the breadth of content areas and coverage required for accreditation. Colleges and universities seeking FEPAC accreditation subject their programs to extensive and thoughtful review and improvement. FEPAC accreditation signifies that a program meets the standards written by a community of academics and practitioners, but few (53 at the time of this writing) programs are FEPAC accredited (33 Bachelor's degree and 21 Master's degree programs at 41 colleges and universities (4)) of hundreds of forensic programs world-wide.

Scientists utilize the scientific literature and published standards to create protocols and standard operating procedures (SOPs). The scientific literature is written by scientific experts and professionals. Papers detail methods and instrumentation settings used to collect data and distinguish or qualify materials as well as the level of uncertainty of the analyses. Millions of scientific papers have been published with a reported 2.82 million in 2022 alone (6). Through 2009, 50 million papers had been published since the year 1665 (7). It is impossible to read all of the historical literature and publications appearing at such a staggering pace. However, the literature is invaluable in validating and assessing the reproducibility of methods with evidence-type materials and circumstances, and publication is a significant factor to admissibility into court. In teaching about the history, theory, and advances in scientific topics, faculty need to focus and be selective with the literature to meet their goals, needs, and constraints. Thus, no graduates have identical training or experiences in their degree programs especially when factoring in student research papers, presentations, and independent research project goals and novel findings. As an example, curriculums vary in American Chemical Society (ACS) accredited undergraduate programs as well, but ACS-certified chemistry graduates get hired and are well-regarded by the chemical industry. A report showed that undergraduate degrees in physical and natural sciences are preferred for entry level candidates (8) in forensic laboratories potentially due to the emphasis on theoretical underpinnings of the science in those degrees.

A mission of colleges and universities is to prepare students for a changing world rather than the current operational standards. Accordingly, laboratories must train their staff and new hires in the methods and techniques in their standard operating procedures (SOPs) and fill in gaps in their knowledge and experience.

To ensure that the analyses and results obtained from evidence testing are consistent across the United States, standards have been collaboratively written by forensic science academics and professionals and published by various standards development organizations (SDOs), including the American Academy of Forensic Sciences (AAFS) Academy Standards Board (ASB). American National Standards Institute (ANSI) / ASB standards cover topics including training and best practices in forensic DNA analysis and interpretation, forensic toxicology, age estimation in anthropology, examination of human remains in forensic anthropology, friction ridge examination, document examination, death analysis, firearms and tools analysis, bloodstain pattern analysis, crime scene reconstruction, footwear and tire analysis, and serological analysis (**FIGURE 1**) totaling 130 published standards at this time [9]. Many of the ASB standards are listed on the National Institute of Standards and Technology (NIST) Organization of Scientific Area Committees (OSAC) Registry (www.nist.gov/osac/registry) which is a repository of selected published and proposed forensic science standards.

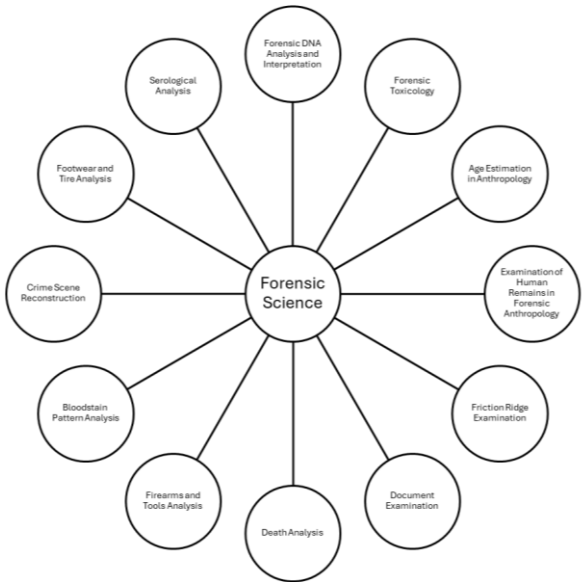

FIGURE 1 Topics of ANSI / ASB published standards

One of the standards, ANSI/ASB Standard 115, *Standard for Training in Forensic Short Tandem Repeat Typing Methods using Amplification, DNA Separation, and Allele Detection*, 2020, 1st Ed. has standardized the concepts and topics for laboratory trainers to teach but not the actual curriculum (10). I engaged in conversations with both laboratory directors and NIST staff about this gap; Towson University applied for funding under NIST's Measurement Science and Engineering Grant Program and was awarded a cooperative agreement in September 2023 to address this gap.

Herein the collaborative process and goals are described including assembling and working with an external advisory board, surveying and interviewing laboratory directors and their designees on their forensic DNA training programs, development of a standardized

forensic DNA curriculum and assessment tool, and dissemination of deliverables. The collaborative model that has been developed could be replicated and implemented in other forensic disciplines including forensic toxicology, forensic anthropology, and pattern analysis.

Materials and Methods

The team, composed of academic, FSSP Director, and government representatives, identified that ANSI / ASB Standard 115 was a good candidate for curriculum development and standardization (**FIGURE 2**) and the principal investigator (PI) assembled an external advisory board with laboratory directors from city and state public FSSPs to discuss the tenets of their new hire training programs for forensic DNA analysts. Upon receiving funding, the university team including the PI and graduate student assistants independently reviewed and mapped training documents provided by the advisory board members' labs and others publicly available on the World Wide Web to the items outlined in ANSI / ASB Standard 115. A survey and interview questions were prepared to better understand the emphasis, required readings, teachings and assessments in public and private FSSP training plans. The team also toured county, city, and state labs of varying sizes to understand space and instrumentation differences, training approaches, and constraints.

The survey and interview research goals and interview instruments were submitted to the Towson University Institutional Review Board (IRB) for review. Upon revision and IRB approval (#2160), the surveys and interviews were conducted from February to May 2024. Interviews were conducted with laboratory directors and their designees, including trainers and technical leads, about their training challenges and needs. The survey questions are published with the corresponding report (12) and the interview paper is in preparation. The mapping and interview results were used to guide the development of curriculum materials including PowerPoint slides, quiz questions, and suggested readings aligned to ANSI /ASB Standard 115.

A question writing team was formed to develop an assessment question item pool. The assessment items were multiple choice, written and selected for coverage by a collaborative team, edited by the PI, and tested at a FEPAC-accredited program. With IRB approval, data was collected from test takers outside of the writing team via administration by a faculty member outside of the research team. An item analysis was performed, and the best performing items and coverage were selected for the assessment tool using the approach of the American Chemical Society (ACS) Exams Institute (EI) (11). Several statistics were determined including average score, standard deviation, reliability, standard error of measurement, most common distractor, and difficulty and discrimination of each item using a published method (11).

Abstracts were submitted to relevant national and international forensic science meetings including the 35th International Symposium on Human Identification (ISHI) in 2024, American Academy of Forensic Sciences (AAFS) Annual Meeting in 2025, and the American Society of Crime Laboratory Directors (ASCLD) Symposium in 2025 to disseminate the results of the project and make the community aware of the new tools and resources generated through this project.

The collaborative model and process is diagramed in **FIGURE 2**.

FIGURE 2 Collaborative model developed to achieve the curriculum and assessment tools aligned to ANSI / ASB Standard 115

Results and Discussion

The Importance of Standards and Partnerships

As previously described, dozens of consensus-based standards have been written and published. Standards seek to improve the quality and consistency of forensic training, results, interpretation, and reporting. Prior to beginning the curriculum development portion of the project, we performed a landscape analysis. We toured five laboratories of a range of sizes from small to medium to large to very large at the state, city, and county level. We mapped training materials and manuals from approximately a dozen laboratories across several states, conducted interviews with a dozen lab directors, technical leads and trainers in nine states, and received survey responses from 32 lab designees from 21 states (12).

Through touring labs and interviewing laboratory directors, technical leads and trainers, we were better able to understand the tenets of and how the training plans were implemented in practice and if there were space constraints or other options for training. Furthermore, as FSSP leaders talked with us about the project goals, their training plans and responded to the survey instrument, more were willing to share their training documents with us thus allowing us to expand our mapping and understanding. Additionally, discussions with FSSP leaders and trainers were essential to avoid assumptions

about training goals and include the appropriate content and coverage in the service environment. Discussions with leaders from labs of all sizes were essential to understand approaches and tools used in forensic DNA testing.

Curriculum Development

The curriculum content was developed *de novo* and aligned directly to the standard. The goal was to prepare a curriculum addressing the topics outlined in ANSI/ASB Standard 115; adoption of the standard by participating FSSPs does not signal a uniform curriculum is used any more than certification or accreditation of programs by ACS or FEPAC, respectively, signifies curriculum standardization across universities. Monthly feedback on the project progress, content coverage, and curriculum development was provided by NIST staff.

The training materials created were central to this project and cover history, theory, methods, instrumentation and approaches used by various labs. Tasks included writing curriculum content on PowerPoint slides, creating or sourcing figures, tables and diagrams, and assembling a suggested readings list. This project focused on the knowledge-based portion of ANSI / ASB Standard 115 which included these nine topic areas: "STRs in forensic DNA analysis, polymerase chain reaction, DNA separation, DNA detection, instrumentation and reagents, contamination, quality control in the amplification, DNA separation and allele detection process to include appropriate controls, storage, preservation, and retention of amplified DNA product according to laboratory policy, and troubleshooting" (10).

The approach to the curriculum was alignment to training documents, coverage of ANSI /ASB Standard 115, quality presentation, and cohesion. In total over 400 slides were created covering the knowledge-based topics. Specialized tasks such as generating new figures were undertaken by team members. Content was drawn from the literature, textbooks, instrument and kit user manuals, published standards, and laboratory experience. Initial review and feedback was provided by NIST staff. Feedback from the community of trainers and lab directors was requested in presentations at the fall ISHI and AAFS conferences. Additional feedback was provided by graduate assistants.

The content addresses required FEPAC content and learning outcomes described in syllabi in taught in courses in FEPAC-accredited programs, but the organization and coverage of the material may vary and span multiple courses; for example, the coverage presented for a forensic DNA biology course (13) that is supported by major textbooks in the field differs somewhat from ANSI / ASB Standard 115. Notably, serology is not included in ANSI / ASB Standard 115 but is included in most undergraduate forensic biology courses. This particular standard does not explicitly include interpretation, but single source and mixture interpretation are covered in undergraduate and graduate forensic biology and DNA typing courses. ANSI/ASB Standard 115 also does not cover probabilistic genotyping which may be included in advanced forensic science courses and many labs today employ. Another difference between coursework and a working forensic laboratory is instrumentation. Instrumentation students used in academic labs may be different than what they will use when they are hired in a forensic lab. Furthermore, faculty may teach only instruments in their labs that students will use and not cover instruments their teaching labs are not equipped with but may be found in working forensic labs.

The curriculum may be suitable for implementation at colleges and universities. The curriculum content produced in this project is disseminated on a public website (https://wp.towson.edu/dna-training-curriculum/curriculum/) and is available at no cost to users. The curriculum, aligned to ANSI/ASB 115, suggests prominent books and other standards as readings but is not itself a specific textbook like most courses assign. Most instructors and students prefer a single text rather than multiple texts and numerous open educational resources. While forensic trainers are focused on addressing legal requirements, laboratory needs and casework, academics are focused on teaching curricula that has passed muster with multiple levels of committees and state and Higher Education accreditation body approvals.

Refinements to the curriculum will continue to be made based upon feedback received. On the web platform, views can be tracked but no user accounts are required. If implemented, laboratories and universities will need to independently decide upon credit given toward training goal completion or course student learning outcome following access and use.

Specialized Project Management Knowledge and Research Skill

Approaching a project such as this for another standard will require significant personnel or faculty time for developing the curriculum and collecting feedback. Additionally, leading teams and writing assessment items require specialized knowledge and skills (14) including project management, knowledge and experience with survey and interview research, statistics, and IRB submission and review. The survey and interview items were created for this project and IRB approval was secured for the survey and interview items prior to administration. Preparing the survey and interview questions and then analyzing that data qualitatively and quantitatively is time-consuming and a specialized skill. It is important to have team members with diverse perspectives and strengths. In this case, experience in

these realms was gained through education, professional development in social science research methodology, and ACS Exam Institute Workshops and ACS EI Exam Committee work.

Development of an Assessment Tool

Standardized exams are used worldwide to gauge student learning and competency on topics. Collaboratively developed and validated assessment tools are used by organizations including the ACS EI, The College Board, and the American Board of Criminalistics for its Forensic Science Assessment Test (FSAT). Typically, the ACS EI recruits 12-16 experienced educators to create an exam writing team. The team meets for 3 weekends over 1.5 years (often preceding or following ACS or Biennial Conference on Chemical Education (BCCE) meetings) to decide upon topic coverage selection and item development and revision. Two beta examination tools are produced of 60-70 items each and tested at U.S. colleges and universities over the next 1-3 years. The average score, standard deviation, item difficulty and complexity are computed (11). Selection of the final items for the release test is based upon the item performance and balancing the difficulty, discrimination, and complexity (15). The trial stats are used to select the items for the release test.

In this project, the assessment tool was developed under a much shorter timeline with a much smaller and different team to meet the project deadline. Six item writers including one academic faculty member and five graduate students collaborated on the development of the assessment tool during the Fall 2023 semester leading to an initial pool of approximately 275 items covering the knowledge-based topics STRs in forensic DNA analysis, PCR, DNA separation, DNA detection, instrumentation and reagents, contamination, quality control, storage, preservation and retention and troubleshooting. Topics such as serology, safety, and laboratory specific history or policies were not included. A total of 110 multiple-choice items (equivalent of approximately two beta tests) were selected for their range of ANSI / ASB Standard 115 topic coverage and content and formatted for testing. For the beta testing, twenty-four participants were recruited from undergraduate and graduate forensic DNA courses at a FEPAC-accredited forensic program in the Fall 2023 and Spring 2024 semesters. The assessment was administered by a faculty member not associated with the study or item development. The submitted data was recorded without names and analyzed in Microsoft Excel. The results exhibited a narrow Bell curve and a normal distribution. The average scores in the testing were lower than a typical training passing score of 80% in forensic laboratories (12) or B grade in college courses. This may be attributed to the need for the student participants to gain further training or study of the material, that the bar is set too high, or that the items need revision or removal.

Items that had a negative or zero discrimination index were removed. Further modifications may be made upon feedback from the forensic community following wider use. The assessment tool was created following the initial mapping while the IRB was under consideration and administered following approval. Writing the items after developing the training content and having experienced faculty item writers (similar to the ACS EI approach) would strengthen the approach, but this was not possible due to the short time constraints to conduct the beta testing and having limited test takers and item analysis. The number of test takers was limited by the course enrollments and timeline. More data will be collected as trainees and students from additional institutions take the test and new versions will be prepared based upon the data. The assessment tool is available to bona fide trainers, instructors and faculty via communication with the author.

Outcomes and Training Materials

The research and curriculum outcomes of the project were substantial and included the curriculum slides and assessment tool as well as two research papers detailing the results of the survey (12) and interview research (in preparation).

An unexpected outcome was the development of the new collaborative model (**FIGURE 3**). The curriculum development and design depends on the inputs from the ASB consensus body, teaching faculty, grant funders and project management staff, directors, trainers and end users, and assessment team item writers. This collaborative model can be applied to other forensic disciplines and may reduce onboarding training time and standardize trainee knowledge.

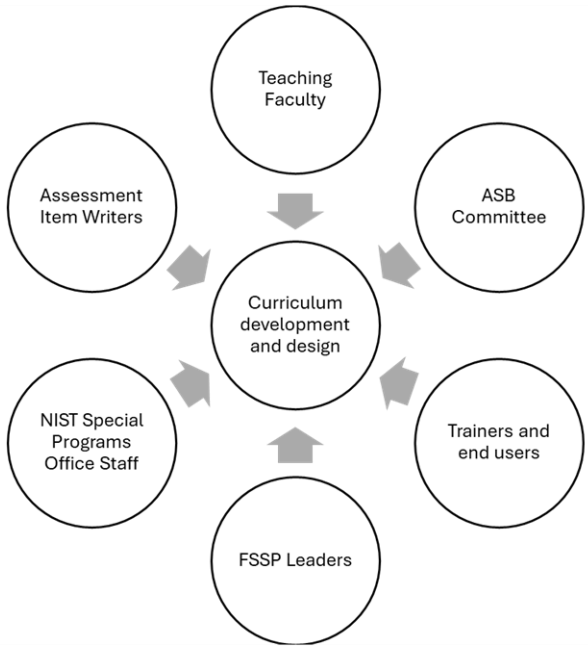

FIGURE 3 Collaborative model and partners

Bridging the gap between academics and practitioners and college and university graduates and hired workforce trainees has been a goal of collaborative teams within FEPAC and ASCLD. Learning from a standardized curriculum at the college or university level is expected to reduce the time in training upon hire to a FSSP. It may also lead to better prepared hires. However, the goal of education is to provide breadth and foster critical thinking skills and not all students continue to jobs in forensic laboratories. These hypotheses and the success of the model will need to be assessed in the future with data. Widespread adoption by academic programs and laboratories may be necessary to collect sufficient data to conclude its effect. However, there is value in standard reaching initiatives even absent full adoption of curriculum tools and ANSI/ASB standards by laboratories and academic programs.

The curriculum slides and exam have been developed to align with standard ASB/ANSI 115; this content is taught at universities worldwide to advanced undergraduate and graduate students under a variety of course titles and numbers including DNA Technologies, Forensic Biology, and Forensic DNA Typing. The tools are suitable for learning by students, recent graduates, and trainees.

Conclusion

Collaboration is central to the model described in this paper. A qualified, experienced and diverse team needs to be assembled to conduct a project such as this. It was essential that as many voices and perspectives were considered as possible and that each stage is collaborative. The OSAC and ASB collaborated to draft the standard; the public had an opportunity to provide comments; it was published and then reviewed for placement on the OSAC Registry (16). In this project, laboratory leaders provided an external advisory perspective, offered laboratory visits, and provided training materials for review and mapping by an independent team. Anonymous respondents responded to the survey, described their challenges and needs, and the data was used to guide the development of the curriculum including assessing topic depth and coverage. NIST staff provided feedback on project outcomes and curriculum materials. A team wrote the assessment tool, and a faculty member outside of the project team administered the beta test to students across two semesters.

Ten PowerPoint slide decks were prepared for overview and definitions and each knowledge-based training topic in ANSI / ASB Standard 115. Suggested readings were collected from training plans and materials provided by FSSPs and survey respondents. Quiz study questions were written and adapted from training content and aligned to training materials. A website has been developed to make the curriculum available and disseminate the project outcomes including papers and presentations. The assessment tool can be obtained by contacting the author directly. Following the knowledge-based training, trainees need to shadow and perform practical training in the laboratory environment where they conduct research or are employed to demonstrate competency prior to processing casework.

This collaborative curriculum development model is one that could be replicated and implemented in other forensic disciplines including forensic toxicology, forensic anthropology, and pattern analysis. As of this writing, there are 28 standards for training published by the ASB including serological methods, canine detection of humans, footwear/tire analysis, and testimony for forensic biology (9).

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