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Utilizing Secondary Agricultural Education Programs to Deliver Evidence-Based Grain Safety Training for Young and Beginning Workers

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ABSTRACT

Purdue University's Agricultural Safety and Health Program (PUASHP) has collaborated with secondary agricultural education programs, including FFA Chapters, for over 70 years to deliver and promote agricultural safety and health programming. With support from a U.S. Department of Labor Susan Harwood Program grant, PUASHP utilized a Developing a Curriculum (DACUM) process to develop, implement, and evaluate an evidence-based curriculum for use with young and beginning workers, ages 16–20, exposed to hazards associated with grain storage and handling. The primary audience was students enrolled in secondary agricultural education programs. A review of the literature identified a gap in educational resources that specifically addresses this target population. The curriculum developed was based on fatality and injury incident data mined from Purdue's Agricultural Confined Space Incident Database and input from a panel of experts. The process identified 27 learning outcomes and finalized a pool of test questions, supported by empirical evidence and confirmed by a panel of experts. An alignment process was then completed with the current national standards for secondary agricultural education programs. Seventy-two youth, ages 16–20, enrolled in secondary-school agricultural education programs, and a smaller group of post-secondary students under the age of 21 interested in working in the grain industry pilot tested the curriculum. Based on student and instructor feedback, the curriculum was refined and submitted to OSHA for approval as part of OSHA's online training resources. The curriculum was delivered to 3,665 students, ages 16–20. A total of 346 pre- and post-tests were analyzed, and the results used to confirm content validity and assess knowledge gain. Findings led to additional modifications to curriculum content, affirmed knowledge gain, and confirmed appropriateness for use with secondary agricultural education programs. The curriculum has been promoted nationally and made available for free download from www.agconfinedspaces.org. Findings further confirmed the value of delivering safety programming through established programs such as secondary agricultural education programs and FFA Chapters serving youth.

KEYWORDS

Agricultural education; agricultural safety; curriculum development; FFA safety programs; grain safety; young and beginning workers

Introduction

Since 1917, when the U.S. Congress passed the Smith-Hughes Act, secondary-school agricultural education programs have provided millions of America's youth with opportunities for leadership development, personal growth, and career success related to agricultural pursuits. Instruction has been provided through the three fundamental components found in every high school agricultural education program: (1) classroom/laboratory instruction (contextual learning), (2) supervised agricultural experience programs (work-based learning), and (3) student leader organization involvement in FFA.

Currently, over 800,000 students participate in formal agricultural education programs offered by over 11,000 instructors in grades 7 through 12 and adult education programs in all 50 states and three U.S. territories.[1] Instruction covers areas such as agriscience, agricultural mechanics, horticulture, animal science, and environmental science.

These secondary-school agricultural education programs serve as a host for FFA Chapters, with the instructor typically serving as the chapter advisor. In 2016, there were 649,355 FFA members nationally, ages 12–21, in 7,859 chapters located in all 50 states, Puerto Rico, and the U.S. Virgin Islands.[1]

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Agricultural safety and health instruction has always been an integral part of the mission of both agricultural education and FFA activities since their very beginning due to the hazardous nature of agricultural production and related occupations. Over the past 90 years, these programs have played vital roles in promoting activities aimed at reducing the frequency and severity of agriculture-related injuries and property losses, such as hazard awareness, adoption of safe work practices, and healthier life-style choices.

As part of the quality standards developed for agricultural education programs, including the recently developed Agricultural, Food and Natural Resources (AFNR) standards,[2] instructors have been encouraged to incorporate safety education and training on such topics as safe operation of agricultural equipment, safe use of shop tools, appropriate use of personal protective equipment, safe use of chemicals and safety around livestock. These programs have also encouraged carrying out community safety events and participation in local state and national safety competitions.

Through the agricultural education "Supervised Agricultural Experience" (SAE) program, students are provided opportunity to explore careers in agriculture, learn expected work place behaviors (e.g., safe work practices), develop specific skills within an agricultural occupation, (e.g., safe operation of machinery), and apply academic and occupational skills in a real or simulated workplace.[3]

As part of the FFA experience, each student is exposed to additional safety and health learning opportunities. Under provisions of the National FFA Chapter Planning and Recognition: A Student Handbook (2012–2016),[1] chapters are provided guidance on developing a "plan of activities" for promoting safety and health and receiving recognition as a "superior chapter."

Specific quality standards are provided for FFA activities in these areas: Growing Leaders, Building Communities, and Strengthening Agriculture. Safety and health issues are specifically addressed under two of the these areas: Growing Leaders has a component titled *Healthy Lifestyle* — activities that promote the well-being of students mentally or physically in achieving the positive evolution of the whole person; this could include: (i) substance abuse prevention and education and (ii) personal wellness choices and consequences. Strengthening Agriculture includes a component titled *Safety* — activities that enhance safety in the community; this includes: firearm safety programs, ATV safety, equipment operation safety, mock crashes, general farm safety, texting and driving campaigns, and safe animal handling demonstrations.

The Indiana FFA Organization, for example, has established the FFA Living to Serve Safety initiative as a means of encouraging chapters to become involved in making their communities safer places to live and work. Each year, the top ten chapters are recognized at the State FFA Convention. Chapters are also encouraged to ensure that "there is adequate instruction on the safety procedures that pertain to each unit of study" in the agricultural education classroom.

There is no evidence of another formally organized program in the United States that has a greater potential to reach young and beginning workers in agriculture with relevant safety and health information than the current national network of secondary-school agricultural education programs and their sponsored FFA Chapters.

Purdue University's involvement in dissemination of safety programming through secondary-school agricultural education programs

For over 70 years, Purdue's Agricultural Safety and Health Program has been involved, directly or indirectly, in developing and disseminating safety programming through secondary-school agricultural education programs and their sponsored FFA chapters. These efforts have included:

- Promotion of the use of hearing protection for youth operating equipment
- Creation of a statewide fire prevention program involving FFA members conducting fire prevention inspections of their homes and farmsteads
- Implementation of a statewide program to install over 17,000 updated safety decals on older on-farm grain bins
- Development and dissemination of a grain handling safety curriculum to every

agricultural education instructor in Indiana, Michigan, and Kentucky
- Development and dissemination of the "Gearing Up for Safety — Production Agriculture Safety Training for Youth curriculum to approximately 11,000 agricultural education programs in the United States, with funding from the USDA (This evidence-based curriculum fulfills the training requirement for 14–15 year olds seeking employment in agriculture as specified by the Agricultural Hazardous Occupations Order [Fair Labor Standards Act]. It is available as an instructor/leader CD, student CD for independent study, and online at www.agsafety4youth.info. An additional 3,000 copies of the instructor/leaders CD have been distributed to new agricultural education teachers at the National FFA convention.)
- Development of a curriculum introducing agricultural education students to the appropriate and safe use of assistive technologies for persons with disabilities in agricultural workplaces and disseminating it to approximately 11,000 agricultural education instructors and programs in the United States, with support from the USDA
- Distribution of over 3,000 copies of a power take off safety video to agricultural education programs in the Midwest
- Annual safety-related exhibits at the Indiana and National FFA conventions and at the Indiana State Fair FFA Building for more than 25 years[4]

In addition, for nearly 30 years, all agricultural education majors at Purdue University have completed a required course on agricultural safety as part of their teacher preparation plan of study. Additionally, in-service courses for teachers on various safety topics also have been offered. Over 50% of current agricultural education teachers in Indiana have completed a formal safety course and/or received safety resource materials for classroom use presented or developed by Purdue. It should be noted that several other land grant institutions have collaborated with agricultural education programs to sponsor similar initiatives.

Despite all of these safety programming efforts, serious youth-related safety issues in agriculture remain, including — and perhaps especially — in the area of grain storage and handling. To illustrate, in 2010, the Purdue Agricultural Confined Space Incidents Database (PACSID) documented a record number of grain related entrapments and engulfments, with a disproportionate number of the "victims" being under the age of 21. Likewise, more recent analysis of the PACID data have found that persons under 21 accounted for approximately 20% of grain entrapment/engulfment incidents with the fatality rate being about 80%.[5,6] Such "evidence" underscored the need to develop safety training resources and delivery strategies for young and beginning workers involved in grain storage and handling.

This article summarizes the development and implementation process, and testing results, for an evidence-based curriculum titled *Against the Grain*, designed specifically for young workers of ages 16–20 enrolled in secondary-school agricultural education programs. Also presented are the findings from the analysis of pre- and post-tests administered to participants during field-testing of the curriculum, primarily in classroom settings. This work reaffirmed the importance of collaborating with secondary-school agricultural education programs in the delivery of agricultural safety and health programming.

Curriculum development

Goals, desired outcomes, and assumptions

The initial goal of the *Against the Grain* curriculum, when proposed, was to provide evidence-based, basic-awareness-level safety and health training needed by youth who are interested in employment or recently employed in the commercial grain industry or who work on family-operated farms that have grain storage and handling operations. This curriculum was designed for use, primarily, in secondary-school agricultural education programs with flexibility for use by employers at grain operations required to be incompliance with OSHA regulations.

The desired outcomes were a reduction in the number of injuries and fatalities involving youth

engaged in grain storage and handling activities and to increase the awareness of supervising adults of the hazards associated with all types of confined spaces found in agricultural workplaces that pose a risk to younger workers.

The curriculum developers assumed that employers of young and beginning workers in the commercial grain industry recognize their responsibilities to meet OSHA workplace standards, including the training requirements and the personal protection provisions of the CFR1910.272 Grain Handling Standard. This standard requires that employers provide essential training to new employees and equip them with the appropriate personal protective equipment needed to help ensure that they remain safe and healthy at work. Currently, however, the OSHA regulations do not apply to youth employed at agricultural production sites, feedlots, and seed-processing facilities. These unregulated sites account for approximately half of the total U.S. grain storage capacity. The fundamental position taken in the development of the contents of the curriculum was that all youth exposed to grain handling hazards should receive the benefits derived from compliance with the relevant OSHA standards. First, because these standards represent current "best practices," and second, addressing the applicable standards was required as part of the Susan Harwood Grant requirements for curriculum development.

Target audiences

Youth who would benefit most from the proposed training include the following:

- High school agricultural education students and FFA members
- Youth working on family-operated grain farms (the population at highest risk) who likely do not receive the training required at OSHA non-exempt commercial grain operations
- High school students interested in a career or summer employment in agriculture or the grain industry who would benefit if certified as having completed a class on agricultural confined spaces and grain handling safety
- College students preparing for a career in the commercial grain industry
- Beginning workers in the commercial grain industry who did not participate in an agricultural education program or were not otherwise oriented to the hazards associated with the storage and handling of grain

Content development procedure

Since 1978, Purdue University's Agricultural Safety and Health Program has been documenting grain-related entrapment and engulfment incidents and, more recently, asphyxiations, entanglements, falls, and electrocutions in and around all forms of agricultural confined spaces. Over 1,850 cases have been so documented and entered into the Purdue Agricultural Confined Spaces Incident Database (PACSID).[7] Cases involving those under age 21 were analyzed, and the data were summarized.[6] The findings provided the foundation for developing the *Against the Grain* curriculum.

With support from a 2011–2015 Susan Harwood Grant through the U.S. Department of Labor, a formal curriculum development process (DACUM) was initiated.[8] The relevant literature was reviewed, including both injury prevention research related to childhood and young adult workplace injuries, and regulations aimed at providing protection for those under age 18. Utilizing the data found in the PACSID and the review of literature, a list of over 70 potential contributing factors was developed and refined by the project team. The advantage of this approach was that the factors were identified based on information from actual cases involving deaths and injuries to youth and, thus, have high content validity.

The team next determined that the list needed to be prioritized before being used for curriculum development purposes due primarily to the limited amount of time that could be devoted to this type of training, especially in secondary-school agricultural education settings that are required to meet state standards and, in some cases, to comply with National Agriculture, Forestry, and National Resources (AFNR) standards for curriculum content. The prioritized contributing factors would

then provide the basis for identifying the learning outcomes or desired core competencies that would be addressed in the curriculum.

In 2012, a panel of experts was assembled for two days to prioritize the contributing factors, to draft the initial set of desired learning objectives, identify any factors potentially overlooked, and to review samples of potential test questions. This process was led by Dr. Brian French, an educational measurement specialist at the Washington State University. Based on the list of prioritized learning outcomes, a series of five PowerPoint presentations, with supporting instructional resources, was developed that addressed each learning outcome at least once and, in some cases, more frequently due to priority level. Each lesson was designed to be carried out in a 45-minute session or collectively in a three-hour workshop setting.

During the spring and fall of 2013, the draft instructional content was pilot-tested with 4-H youth, secondary-school agricultural education students (grades 9–12), and post-secondary students studying agriculture at Purdue University. A total of 72 youth participated. (The content was also reviewed by agricultural education specialists for its applicability to youth ages 16–21 and for appropriate reading level.) The pilot training consisted of a series of three, 5-hour, out-of-school workshops to test the materials and make revisions as needed. These trainings included three hours of classroom instruction, a one-hour tour of a commercial grain storage facility, and appropriate breaks. Both pre- and post-tests were administered to the 72 participants.

Conducting the voluntary 5-hour sessions during "school time" proved to be problematic due to the inability of secondary teachers being able to commit 5 hours to the training due to the demands to cover other required instructional content. Curriculum content was again reviewed based on feedback and restructured to allow the five "stand alone" lessons, to be taught as five individual lessons or as one out-of-school program during a 3-hour time block with a recommendation to conduct a grain facility tour as a supplemental activity.

Content was also revised based on initial post-test results that showed insignificant knowledge gains. It was concluded that lack of knowledge gain was a reflection of higher-than-expected knowledge level of the subject matter and inadequate test question design rather than curriculum content. Utilizing a second panel of experts, a test-question pool containing 111 questions was developed and examined for content consistency and coverage of the critical areas. This pool was used to draw questions for use with all subsequent pre- and post-testing of training participants and for analysis of knowledge gain.

The material was subsequently submitted to OSHA for review and approved for use as part of the Susan Harwood Program online training offerings. During the spring of 2014, over 600 secondary-school agricultural education students participated in an additional round of testing of some or all of the curriculum components, including completion of either a pre- or post-test. The purpose of this testing was to document the participants' knowledge gain under controlled conditions, including use of the same instructional resources/contents and instructional team. Institutional Review Board approval was applied for and received to conduct this activity.

The curriculum was made available in December of 2014 at the project's website, www.agconfinedspaces.org. Feedback was encouraged from all agricultural educators who participated in the pilot tests of the curriculum and the pre- and post-testing events in secondary schools.

During 2015, an additional 419 young and beginning workers participated in the training. Three train-the-trainer classes on using the curriculum were held for agricultural education instructors. The curriculum was also introduced to approximately 160 Indiana agricultural educators at an in-service workshop, including instruction on accessing the contents from the project website. Lastly, the curriculum was presented to about 40 agricultural education majors at Purdue University prior to their student teaching experience, with each receiving a set of curriculum materials and being encouraged to use them during their student teaching.

The feedback gathered from both students and instructors using an assessment tool provided information that was used to revise the curriculum in the fall of 2015. Those revisions included

additional learning outcomes recommended by reviewers, further enhancement of the pool of test questions validated earlier by a panel of experts, and changing some of the visuals to enhance clarity and address new learning outcomes. The final list of 27 prioritized learning outcomes is included as the Appendix. The revised curriculum was then presented to an additional 321 students enrolled in post-secondary-school agriculture classes and 47 post-secondary-school students seeking employment in the grain industry following graduation. Plus, the curriculum was presented as three 1-hour webinars (sponsored by the *Grain Journal*) that reached over 300 young and beginning workers and safety professionals employed in the grain industry at worksites across the United States.

After the OSHA Susan Harwood Grant Project was completed in December 2015, additional minor revisions were made, based on additional feedback from secondary agricultural education teachers and additional reviewers gathered during the spring of 2016. The current curriculum was also presented to an additional 149 secondary-school students in 2016, with pre- and post-tests administered.

To date, approximately 3,665 youth, ages 16–20, have completed the training by the instructional team. The number of youth exposed to the training by instructors with access to the curriculum online or who were provided "hard copies" is unknown.

Findings

Administering pre- and post-tests

As part of the curriculum development process, four or five test questions were developed and tested for fit to each of the prioritized 27 desired learning outcomes. This 111-question pool is included as part the curriculum and accessible to instructors at the website. The questions can be drawn randomly and administered with reliable results. The pool was used to design pre- and post-tests to assess the curriculum with respect to participants' knowledge gained.

All youth participants in the initial curriculum development process were requested to take a pre-test and then a follow-up post-test upon completion of the training. The initial testing included only five test questions developed by the project team. The five-question strategy was modeled after pre- and post-testing methods used in online instructions. Follow-up testing relied on ten questions drawn from the pool of 111 validated test questions. All testing was voluntary to comply with the Human Subjects Research Committee's approved protocol. The curriculum was administered in three different formats: (1) face-to-face/classroom settings based in secondary-school agricultural education programs; (2) face-to-face classroom-based instruction involving post-secondary-school students enrolled in agricultural safety classes at Purdue University or students seeking future employment in the grain industry; and (3) online webinar-based instruction that included access to professional assistance via email or toll-free telephone number. Pre- and post-testing was conducted in only formats 1 and 2.

Data analysis

Data were analyzed for both the pilot and revised pre- and post-tests using SAS® 9.4. Distribution of scores was not normally distributed. Thus, the non-parametric Wilcoxon Rank Test was used to compare the difference between pre-test and post-test scores.[9]

Results

A total of 138 pre-tests and 231 post-tests were collected from secondary-school agricultural education students during the initial pilot testing of the curriculum using only five questions. As shown in Table 1, the average score of the pilot pre-tests was 95.07, while the average post-test score was 94.93; thus, there was no significant difference between the scores ($p > 0.05$). In other words, the students had greater knowledge of the

Table 1. Pilot test pre- and post-test scores from secondary agricultural education students.

	N	Mean	*SD*
Pre-test	138	95.07	10.2
Post-test	138	94.93	12.34
Pr ≥ |s|	0.9369		

hazards than was originally anticipated. In fact, there appears to be a ceiling effect where on average all students came to the pre-test with excellent levels of knowledge based on the questions used. This high level of pre-knowledge of the subject matter was not anticipated. These findings led to the revisions discussed above including validation of test questions by a second panel of experts, increase in the number of test questions to 10, and revisions to the curriculum contents.

A second round of testing resulted in 275 pre-tests and only 80 post-tests. The average scores of the pre-tests and post-tests were 57.38 and 75.38, respectively. There was a significant difference between the scores ($p < .0001$) as shown in Table 2, with a 31.4% average increase in the scores. Using the revised curriculum, 3-hour training workshops were conducted at Purdue University for upper-level students considering employment in the commercial grain industry and who had completed at least 3 years of college course work in agriculture.

A total of 73 pre- and post-tests were collected from these workshops. Since completion was voluntary, not everyone chose to participate in the testing. The average pre-test score was 96.88, while every one of the 73 test takers received 100% on of the post-test, with no difference between scores ($p > .05$). See Table 3. The p-value was greater than 0.05, which indicated the difference shown by the tests was not statistically significant (Table 3). The standard deviation of the post-test was 0, meaning each post-test got a full score. This also indicated that the test questions were too simple for older post-secondary-school agricultural students.

Table 2. Pre- and post-test scores from secondary agricultural education students using revised question and curriculum.

	N	Mean	*SD*
Pre-test	80	57.38	15.97
Post-test	80	75.38	21.22
Pr ≥ |s|	<.0001		

Table 3. Pilot test scores from post-secondary agricultural students.

	N	Mean	*SD*
Pre-test	32	96.88	7.38
Post-test	32	100	0
Pr ≥ |s|	0.0625		

Table 4. Revised curriculum pre- and post-test scores from post-secondary agricultural students enrolled in agricultural safety class.

	N	Mean	*SD*
Pre-test	96	74.35	21.75
Post-test	96	80.31	8.88
Pr ≥ |s|	<.0001		

Table 5. Combined the revised pre- and post-test scores from secondary agricultural education and post-secondary agricultural students.

	N	Mean	*SD*
Pre-test	176	59.15	16.59
Post-test	176	78.07	15.88
Pr ≥ |s|	<.0001		

Additional training, using the curriculum, was offered to those enrolled in Purdue's agricultural safety and health course comprised primarily of third- and fourth-year students. This training was conducted outside of class, and completion of pre- and post-tests was voluntary. A total of 120 pre-tests and 96 post-tests scores were collected and analyzed. Even though the knowledge gain was much less than that documented with the secondary-school students, the average pre- and post-test scores were 74.35 and 80.3,1 respectively, an 8% increase, which was statistically significant, as shown in Table 4.

When scores are combined for both the secondary-school agricultural education students and the post-secondary-school students enrolled in agriculture, who were administered the final version of the curriculum, there remained a significant difference between pre- and post-test scores, as noted in Table 5, with the result showing a 32% increase from the pre-test.

Conclusions

The project's finding indicates that the *Against the Grain* curriculum, as currently available, when presented to secondary-school agricultural education and post-secondary-school agriculture students, will result in significant increases in knowledge gain regarding the hazards related to grain storage and handling. Those enrolled in secondary-school education programs (the primary target population) showed greater knowledge gain compared to the older participants. There

was less knowledge gain shown for upper-level post-secondary-school agricultural students who completed the training.

Findings suggest that members of the target audience were more familiar with the hazards associated with grain storage and handling than was originally expected, due possibly to the large number of participants in the study being from farm backgrounds or from farms producing grain. This led to revisions in both content and test questions. Participants at opposite end of the age spectrum showed significant differences in their pre-knowledge of the subject matter.

The number of secondary-school agricultural education programs that were willing to incorporate the training into their curriculum was higher than originally expected. During the study, approximately 50 different schools were involved, providing 3,515 students with no less than 6,569 hours of documented instruction.

Another indicator of the curriculum's acceptance is reflected in the number of visitors to the project's website, where instructors may freely download the curriculum contents, test questions, and PowerPoint presentations. During the first year, the site was available. In 2013, it hosted 83 visitors; in 2014, that number grew to 891; there were 5,419 visits in 2015; and the number reached 2,043 in 2016. It is believed that this "healthy" site traffic was due to the distribution of flyers describing the curriculum at the National FFA Convention in 2015 and 2016.

Recommendations

Efforts are under way to further update the curriculum to reflect new findings, specifically those related to non-entrapment-related injuries to young and beginning workers in the grain industry or who may be exposed to other types of agricultural confined spaces such as silos and manure pits. Feedback from users of the curriculum over the past four years is also being incorporated. Further alignment with current agricultural education standards (AFNR) and individual state standards, which continue to be modified, needs to be made to increase the likelihood of the curriculum utilization where these standards have been adopted. More attention needs to be given to encouraging secondary school agricultural educators to recognize the tremendous influence they have over their students in adopting safer worker practices, especially those related to grain storage and handling.

Based on feedback from attendees at the National FFA Convention, there is also a demand for the materials to be made available on a Flash drive or CD due to the slow download speeds at many rural schools that host agricultural education programs. The use of complex, multi-image PowerPoint slides can greatly increase the download time.

It is believed that the findings demonstrate that secondary-school agricultural education programs should continue to be considered as a viable means for delivery of agricultural safety and health programming to youth. It may also be even more effective than the use of safety professionals to reach farmers indirectly through the youth participants with the same content. This collaboration could be further enhanced if the resources were introduced to students in agricultural education teacher training programs across the United States and during in-service training of current teachers.

Considering that the frequency of grain-related injuries and fatalities involving youth is relatively low, and the amount of the time secondary-school educators have to focus on safety and health topics is limited, care needs to be taken to prevent de-emphasizing higher risk behaviors or exposures such as tractor rollovers and falls from equipment. Priorities need to be established based on actual injury data and to ensure that young workers with the greatest risk of exposure are provided training.

Finally, it is believed that the curriculum provides an evidence-based approach to conduct preliminary safety training and testing of young and beginning workers exposed to the hazards of grain storage and handling. Completion of the training would provide important documentation for meeting current OSHA workplace safety regulations.

References

1. National FFA Organization. https://www.ffa.org/home. Accessed June 22, 2017

2. Agricultural, Food and Natural Resources Standards. The national council for agricultural education website. https://www.ffa.org/SiteCollectionDocuments/council_afnr_career_cluster_content_standards.pdf. Published 2015. Accessed June 22, 2017
3. Supervised Agricultural Experiences. National FFA organization website. https://www.ffa.org/about/supervised-agricultural-experiences. Accessed June 22, 2017
4. Indiana FFA Orgnization Website. http://www.inffa.org. Accessed June 22, 2017
5. Riedel SM, Field WE. Summation of the frequency, severity, and primary causative factors associated with injuries and fatalities involving confined spaces in agriculture. *J Agric Saf Health*. 2013;19(2):83–100.
6. Issa SF, Field WE, Hamm K, Cheng YH, Roberts M, Riedel S. Summarization of injury and fatality factors involving children and youth in grain storage and handling incidents. *J Agric Saf Health*. 2016;22(1):13–32. doi:10.13031/jash.22.10954.
7. Issa SF, Cheng YH, Field WE. Summary of agricultural confined-space related cases: 1964-2013. *J Agric Saf Health*. 2016;22(1):33–45. doi:10.13031/jash.22.10955.
8. What is Developing a Curriculum (DACUM)? Eastern Kentucky University facilitation center website. http://facilitation.eku.edu/what-developing-curriculum-dacum. Accessed June 22, 2017
9. Lyons SA, Goodman MS. Community research fellows training program evaluation: using SAS® to analyze pre- and post-test data. New England SAS Users Group 2013, 1-6. http://www.lexjansen.com/nesug/nesug13/115_Final_Paper.pdf. Accessed June 22, 2017

Appendix. Prioritized learning outcomes for *Against the Grain* curriculum

(1) Explain the importance of the grain industry to a viable U.S. economy.
(2) Identify career opportunities for young and beginning workers within the grain industry.
(3) Know that young and beginning workers account for nearly 20% of injuries and fatalities at grain storage and handling facilities.
(4) List those characteristics of young and beginning workers that increase their risk of injury in the workplace.
(5) Describe the general movement of grain from field to final products.
(6) Describe the characteristics of an agricultural confined space, including those regulated under the OSHA standards.
(7) Identify the types of confined spaces that can be found in and around agricultural workplaces, including grain storage/handling operations.
(8) Recognize the primary hazards associated with grain storage, handling, and processing facilities, especially those related to confined spaces.
(9) Explain the difference between an OSHA exempt and an OSHA non-exempt grain storage and handling operation.
(10) Explain the rights of young and beginning workers to refuse to perform certain hazardous tasks for which no training or personal protective equipment has been provided or to file a complaint regarding unsafe work practices under the provisions of the Occupational Safety and Health Act.
(11) Identify the most common contributing factors and injuries involving agricultural confined spaces.
(12) Identify the most frequent types of entrapment, engulfment, and entanglements that can occur in grain storage, handling, and processing facilities.
(13) Understand the characteristics of free-flowing grain.
(14) Recognize the relationship between out-of-condition grain and grain by-products and potential increased risk of entrapment, engulfment, and entanglement.
(15) Identify the key requirements for proper and safe long-term storage of grain.
(16) Identify factors influencing the trend in grain-related entrapments.
(17) Describe the characteristics of a safe and productive worker.
(18) Describe the basic safe work practices that should be followed to reduce the frequency and severity of injuries at grain storage, handling, and processing operations.
(19) Identify the tasks or activities that require use of personal protective equipment based on best safe work practices.
(20) Identify the types of personal protective equipment and clothing used or worn in the grain industry to prevent personal injuries.
(21) Understand the restrictions related to the employment of youth under the age of 16 in agricultural workplaces (including confined spaces) contained in the Agricultural Hazardous Occupations Order.
(22) Understand the added risks that confront young and beginning workers employed on farms not covered by OSHA workplace safety rules.
(23) Explain the rights of all workers to be provided a safe and healthy workplace under the provisions of the Occupational Safety and Health Act.
(24) Describe the steps that young and beginning workers should take to communicate to their employer information about an unsafe work environment or work practices, or their need of training.
(25) Describe the characteristics of an incident that requires an emergency response.
(26) Identify the most frequent types of emergencies at grain storage/handling operations.
(27) List the steps that should be taken in an emergency at a grain storage, handling, or processing facility, including entrapments, entanglements, falls, asphyxiation, heat stress, electrocutions, fires, and explosions.