

An Instrumental Case Study of Effective Science Integration in a Traditional Agricultural Education Program

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Abstract

The integration of science and agriculture has been discussed since the inception of agricultural education. However, the standards-based focus in public secondary education and changing climate of agriculture has brought science integration back to the forefront. Though research has indicated that the integration of science into agricultural education is effective in improving student achievement in science, there are still challenges. The instrumental case study sought to understand how Mr. Lee effectively integrated science into a traditional program while maintaining the benefits and purpose of agricultural education. Six issues, deduced from literature related to the integration of science in agricultural education, were identified. Six themes emerged that elucidate the process of successful science integration. First, agricultural educators' science content knowledge must be strengthened. Second, the pedagogy of scientific inquiry lacked components necessary for a rigorous curriculum. Third, agricultural educators who desire to integrate science should dig into their curriculum for existing science content. Fourth, collaboration among agriculture and science teachers can be fostered through involvement in the science department, and fifth the agricultural educator plays a fundamental role in curriculum planning to increase secondary science achievement. Finally, actual integration occurred in a more segmented way than proposed by Robert's and Ball's (2009) content and context dual-model.

Keywords: science integration; science achievement; scientific inquiry

Local Teacher Wins National Award

Mark Lee, high school agricultural educator at Franklin High School, was recently named the National FFA Agriscience Teacher of the Year. The award recognizes a national outstanding agricultural educator each year that demonstrates effective science integration. "This honor probably came as somewhat of a surprise to many, as at first glance the Franklin agricultural education program looks like every other program in our state," said Mr. Jones, Franklin High School principal. However, when one enters Mr. Lee's facility and observes what is happening, speaks to students, and interacts with Mr. Lee, there is more science than meets the eye. Mr. Lee shared, "I'm glad I am an agriculture teacher and not a science teacher. I really have the chance to make science come alive through agriculture." After spending a few minutes

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with Mr. Lee, it is clear why he was chosen as a national model for science integration. His unique approach stays true to the ideals of agricultural education while integrating science where it naturally fits into the curriculum. This is a program where both stick welding and science have a place, where students are engaged, and where a passion for learning permeates the air.

The vignette touches on the surface of an instrumental case study designed to understand better the processes of science integration in a traditional agricultural education curriculum. Through this study, we uncover not only the glory and honor of the award but also highlight some of the consequences of becoming the National FFA Agriscience Teacher of the Year. Mr. Lee shared with us that he was proud of his accomplishment but the journey was challenging. On one hand, a science teacher at his school questioned the rigor of the program, and on the other hand, Mr. Lee believed the agricultural community in his state questions his commitment to teaching agriculture. This instrumental case study highlights the challenges and tensions inherent in integrating science into agricultural education, while offering suggestions for smoothing the path for others committed to this worthy endeavor.

The No Child Left Behind (NCLB, 2002) Act of 2001 increased pressure across the K-12 curriculum to improve students' knowledge and performance in Science, Technology, Engineering, and Mathematics (STEM) content areas. In response, the American Association of Agricultural Education called for enhanced STEM core content integration in the secondary agricultural education curriculum (Doerfert, 2011). However, integrating science into the agricultural education curriculum can be challenging and complex. Studies have confirmed the predominant idea that integrating science into agricultural education creates a win/win situation (Chiasson & Burnett, 2001; Enderlin, Petrea, & Osborne, 1992; Myers & Dyer, 2006; Myers & Thompson, 2009; Ricketts, Duncan, & Peake, 2006; Rogue & Russell, 1990). Others have questioned if the decision to integrate science deemphasizes other key components that make agricultural education programs unique and successful (Scales, Terry, & Torres, 2009). Myers and Thompson (2009) suggested the examination of exemplary programs that effectively managed the complicated task of science integration. The research reported here addresses the call by documenting, via instrumental case study methods (Stake, 1995), how one agricultural education teacher navigated the integration of science into the curriculum while also highlighting pitfalls along the journey.

Mr. Lee (pseudonym), the primary actor in the case, is a secondary agricultural educator in a rural community situated in one of the most traditional and conservative states in the nation. He was purposefully selected as an exemplar for his effective and highly celebrated science integration values and practices. As researchers, we brought two different perspectives to the interpretation of the case. I taught agricultural education in a large suburban high school where science integration was the expected focus for the curriculum. My research partner taught in a traditional agricultural education program in the same state as Mr. Lee. A typical program, as defined by the research team, is one that included a heavy emphasis on livestock production and exhibition, power and technical systems, plant and soil sciences, and heavy involvement in the contest structures available through the state and national FFA association. We were drawn to this case because Mr. Lee, the teacher and advisor of what appears to be a very typical agricultural education program, was named the National Agriscience Teacher of the Year. We wondered, how was it that an agricultural educator in rural Oklahoma, where science content is often discussed as a secondary role of agricultural education, could become a national model for science integration? Specifically, we wanted to address one main focus issue: How did Mr. Lee effectively integrate science into a traditional program while maintaining the benefits and purpose of agricultural education?

A Search for Understanding

Instrumental case study methods (Stake, 1995) were used to address the focus issue through a thick and rich examination of how Mr. Lee integrated science into his agricultural education program at Franklin High School. The case was bound both by time (a single semester) and program (Franklin High School's agricultural education program). The study was identified as instrumental because it helped us to better understand one aspect of the case, science integration (Stake, 1995). Instrumental case study protocols provided us the freedom to select a case that "maximized what we can learn" (Stake, 1995, p. 4). The Franklin High School agricultural education program, led by Mr. Lee, is an unusual or exemplar case as it was identified as a national award winner. Stake explained that, "often an unusual case helps illustrate matters we overlook in typical cases" (p. 4). In addition, the bounded case was cooperative, as Mr. Lee was willing to participate in the study. It is important to note that the purpose of instrumental case studies is to understand and learn at a deep level about one specific case. Thus, we offer no generalization in the classic definition; however, others may transfer learning from this case should the circumstances be similar.

Procedural, situational, relational, and exiting ethics served as anchors throughout the research process (Tracy, 2010). To students and faculty at Franklin, it was explained that we were very interested in learning more about how Mr. Lee integrates science, and then sharing that information with others to better inform practice. During the first site visit, we negotiated our involvement with Mr. Lee and his teaching context. We agreed to two long interviews with Mr. Lee, observations of classroom activities, and the opportunity to collect documents and artifacts. Embedded throughout the process were opportunities for Mr. Lee to react to various documents and emerging hypotheses. Our requests of data were consistent with the recommendations of Yin (2003) for thoroughly documenting the case. Mr. Lee was encouraged to be an integral part of the study by actively sharing, exposing, and critiquing the story of science integration as we jointly described it.

Merriam (1988) posited "data collection and analysis is a simultaneous activity in qualitative research" (p. 151). The primary data were interviews that occurred during school planning hours in Mr. Lee's office. Two long interviews were conducted with Mr. Lee that followed a semi-structured protocol allowing us freedom to follow emergent ideas and ask probing questions. The interviews were recorded and transcribed verbatim and were one hour in length. In addition to the interviews, we performed teaching observations that allowed for prolonged engagement in the field that made it possible for a more accurate representation of the phenomenon (Creswell & Miller, 2000). We observed Mr. Lee teaching two classes and noted emergent patterns. Further, we took pictures of the naturalistic environment as well as collected important artifacts such as curriculum, assessments and news articles. Mr. Lee was integral in identifying key artifacts of interest.

During and after data collection, we independently coded each interview, field notes, documents, and pictures using ATLAS.TI[®] computer software. Coding and triangulation was employed to develop pre-categorical themes. After all pre categorical themes were developed, we met to negotiate and discuss disconfirming evidence with Mr. Lee (member checking). This process, in accordance with conventions put forth by Creswell and Miller (2000), provided an opportunity to reexamine the data and double-check pre-categorical themes to confirm or reject a specific theme.

In line with situational and procedural ethics, we utilized peer debriefing following each visit to the site. This provided an opportunity to discuss emergent themes and adaptations to protocols based on various situations that arose. Audit trails and member checks addressed procedural ethics by striving to ensure validity of the study. According to Creswell and Miller (2000), "a peer review or debriefing is the review of the data and research process by someone who is familiar with the research or the phenomenon being explored" (p. 129). We debriefed

with four former agriculture educators and two faculty members at Oklahoma State University to assist us in clarifying our interpretations. Further, “the goal of a formal audit is to examine both the process and product of the inquiry, and determine the trustworthiness of the findings” (Creswell & Miller, 2000). We kept an accurate record of all research decisions and activities. An external member of the team at Oklahoma State University reviewed these documents. Finally, member checking consisted of “taking data and interpretations back to the participant in the study so they can confirm the creditability of the information and narrative account” (Creswell & Miller, 2000, p. 127). Mr. Lee was given a copy of all transcriptions and narratives to improve accuracy of the study. In line with Tracy’s (2010) exiting ethics, it was agreed that following the second full day at the site, we would exit and continue the process via electronic mail and telephone as to minimally disrupt the classroom setting. Careful attention was given to the ethical considerations when identifying and describing this case and deciding how the story would be told.

Description of the Case

As we drove into Franklin, the “Pipeline Crossroads of the World” according to a sign at the edge of town, we passed pastures of oil wells and storage tanks, the *new agriculture* of the area as Mr. Lee explained. At the community’s edge was the typical freshly painted FFA chapter “Welcome to Franklin” sign with a large gold FFA Emblem, show hog, show steer, and show lamb cut out of metal. The Franklin agricultural education department was a two-teacher department. Mr. Lee primarily focused on the classes involving horticulture, greenhouse management, and botany. His teaching partner was not science certified and focused on agriculture power and technology, electrical systems, and animal science from a production standpoint. This two-teacher duo worked well together but they clearly knew and voiced their differences in instruction and focus.

Mr. Lee was middle-aged and rich with experience as a result of 21 years in an agricultural education classroom. He began teaching in a traditional production-focused program. Mr. Lee is science certified and reported that certification is an important process for agricultural educators that wish to integrate science. Like most agricultural educators, Mr. Lee was often overwhelmed with plant sales, career development events, student agriscience projects, and school politics. Following the bell, Mr. Lee and his cooperating teacher came out of their offices to greet the students as they pulled a vinyl barrier across the classroom separating it into two different rooms. This physical and philosophical division would prove to be a very meaningful component in the development of a viable agricultural education program that served multiple roles. In reflection, the case was not what we expected as we began our first observation. Our initial bias, based on previous knowledge and experience, was that this program did not *look* all that innovative; however, we would soon discover that the *status quo* appearance is what made this program truly innovative and useful to the mainstream agricultural educator.

Conceptual Lens

We, as researchers, entered the case with the conceptual lens proposed by Roberts and Ball (2009) whereby agricultural education maintains a duality of purpose – agriculture as the content and agriculture as the context (see Figure 1). The role of agricultural education in local communities has changed as education, society, and agriculture has grown and evolved (Roberts & Ball, 2009). As a result, the majority of agricultural education programs have, at least anecdotally, adopted this dual model. However, it is unsure if the curriculum has been modified to align with the dual model, the context model, or the content model (Roberts & Ball, 2009). Based on a lack of empirical support substantiating which of the proposed models is applied in contemporary agricultural education programs, Roberts and Ball (2009) suggested, “that research

be conducted to assess the role of agriculture in agricultural education programs across the country” (p. 88). Furthermore it was recommended that “an assessment of agricultural educators’ philosophies be gathered and further analyses be conducted regarding the extent to which these philosophies guide existing program structures” (Roberts & Ball, 2009; p. 88). What was Mr. Lee’s philosophy related to the content/context conceptual framework? How did this philosophy align with the actual practices in the classroom? Do the variables contained within the model proposed by Roberts and Ball (2009) provide a comprehensive reflection of what is occurring in this unique case? This conceptual framework guided the data gathering and interpretation process.

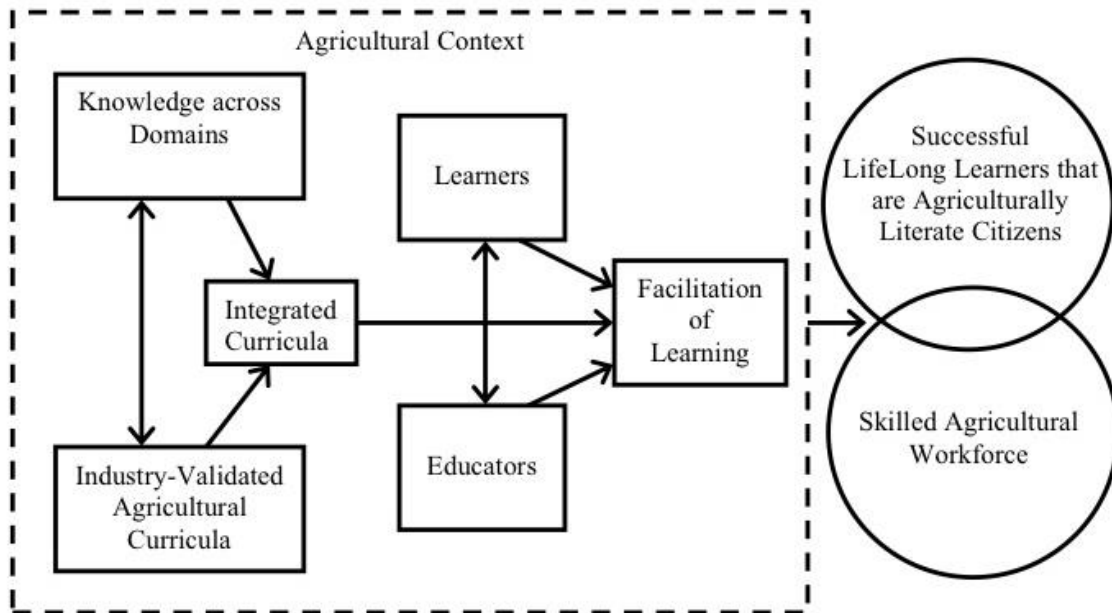


Figure 1. Original conceptual model for agricultural subject matter as a content and context for teaching. Reprinted from “Secondary Agricultural Science as Content and Context for Teaching,” by T. G. Roberts, and A. L. Ball, 2009, *Journal of Agricultural Education*, 50, p. 87. Copyright 2009 by the American Association of Agricultural Education. Reprinted with permission.

Development of Issues

Stories, like that of Mr. Lee’s, are becoming more prevalent in the agricultural education community as core content, especially science, is integrated into the traditional agricultural education program structure. This movement gained attention in 1988 when the National Resource Council (NRC) recommended updating the agricultural education curriculum to include the addition of “sciences basic to agriculture, food, and natural resources” (NRC, 1988, p. 35). This focus continued as made evident by a more recent report, *A New Biology for the 21st Century* (NRC, 2009), that brings attention back to science integration and noted that only through science will agriculture continue to meet the constant societal needs in food, the environment, energy, and human health.

As a result, science integration has received much attention in the literature to explain and understand better the processes associated with the philosophical shift towards agricultural education, not only as delivering agricultural content, but also as an augmentation of science instruction. Generally speaking, agricultural educators, school administrators, parents, and

science teachers hold a positive perception of agricultural education serving as a context by which science content can be taught (Dyer & Osborne, 1999; Johnson & Newman, 1993; Myers & Thompson, 2009; Myers, Thron, & Thompson, 2009; Thompson, 2001; Warnick, Thompson, & Gummer, 2004; Pavelock, Vaughn, & Kieth, 2001).

A number of studies have explored whether agricultural education was an effective avenue to build and enhance core content knowledge. Roegge and Russell (1990) found that an integrated approach to teaching science is superior to the more traditional approach as was evident in the enhanced applied biology achievement. In addition, students reported a better attitude toward the learning experience when science was integrated. Chiasson and Burnett (2001) reported that “agriscience students achieved significantly higher overall scores than non-agriscience students on the science portion of the GEE [Graduate Exit Examination]” (p. 68). Myers and Dyer (2006) began to dig deeper by exploring what type of science integration was most effective and found that an inquiry-based, investigative approach, that is well suited to agricultural education programs, produced greater gains in science processing skills and content knowledge.

The literature outlines benefits to science integration; however, the Agricultural Education profession questions whether it diminishes or detracts from the purpose of agricultural education. Scales, Terry, and Torres (2009) gave voice to this issue and explained that, “...the conventional wisdom of integrating more science, mathematics, and reading into the secondary agriculture curriculum must be carefully considered. Leaders and stakeholders of secondary agricultural education must recognize that such a change will likely alter the very purpose of the program” (p. 109). They continued to outline a number of issues to be considered including how teacher certification may change, how integration may affect Supervised Agricultural Experiences (SAE), how teacher in-service may change, if agricultural principles would be left behind, and what type of student will be attracted to the program. The benefits of science integration are numerous; however, the drawbacks have been under reported, especially the issue of how agricultural educators can maintain the elements of agricultural education that have been central in the success of the program while integrating science.

Another key issue addressed in our case study was rooted in the idea of collaboration. Futrell (2010) explained that to transform schools in America, faculty must remove silos within schools to create interdisciplinary learning environments. Stephenson, Warnick, and Tarpley (2008) sought to better describe the collaborative process between science and agricultural educators. They found that although both parties held positive perceptions of collaboration, they demonstrated limited interaction. Other researchers (Conroy, 1999; Conroy & Walker, 2000; Leonard & Leonard, 2003; Schmidt, 1992, Thompson, 1998) found that a lack of time was the most often reported barrier to collaboration. Stephenson, Warnick, and Tarpley (2008) also discussed that there were territorial contention and competition between science and agriculture departments based on misconceptions that must be addressed. The literature highlights a central issue – how does agricultural education foster more effective collaboration between science teachers and agricultural educators?

Another case study (Grady, Dolan, & Glasson, 2010) sought to understand how an agricultural educator, Sara, operationalized scientific inquiry in her classroom. The researchers found that Sara misunderstood inquiry as a mechanical set of scientific inquiry rather than the six step process outlined by Llewellyn (2002). “Her directions and discussions centered on the routine rather than the reasoning involved in experimentation” (p. 13). Students in her classes struggled to discuss their findings, manipulate the experiments, defend their conclusions, or identify the purpose of the experiments. Sara summarized the finding of her classroom experiments as a pre-formatted structure for the students to follow in their final report of the findings rather than creative expressions of inquiry.

Scales, Terry, and Torres (2009) gave voice to another issue in their article *Are teachers ready to integrate science concepts into secondary agriculture programs?* The research

concluded that teachers were not prepared to integrate science effectively. Though agricultural educators perceived that they were competent to teach nearly all science concepts, less than 10% of the teachers involved in the study scored high enough on an examination to indicate proficient knowledge of biological science. This finding raises the issue, are agricultural educators competent enough to teach science subject matter?

Focus of the Case through Issues Identification

The use of *issues* as a conceptual structure and as primary research questions “forces attention to complexity and contextuality” and “draws attention to problems and concerns” (Stake, 1995; p. 16). The problems associated with science integration in agricultural education draw us, as researchers, to the complexity associated with the case being examined (Stake, 1995). The literature assisted us in framing our case study by highlighting six specific issues that guided data collection and analysis. Issue 1: How did Mr. Lee, an agricultural educator, effectively integrate science into his agricultural education program? Issue 2: How did Mr. Lee maintain the elements of agricultural education that have been integral in the success of the program while adding the role of science integration? Issue 3: Did Mr. Lee effectively implement scientific inquiry into agricultural education lessons? Issue 4: Was Mr. Lee equipped with adequate science knowledge? Issue 5: Was Mr. Lee effectively collaborating with science staff?

Assertions and Conclusions

Assertions are claims to knowledge made by the researchers as a result of data analysis in a qualitative case study. They highlight salient findings and are followed by conclusions or inferences regarding the nature of the case. It is most appropriate to present the case in this fashion for clarification of themes and their implications to practice.

Enhancing Science Content Knowledge

Roberts and Ball (2009) warned that if agricultural education is to adopt a dual-purpose model, teacher education must be evaluated to ensure that teachers are equipped with the skills necessary for the different role. This recommendation resonated as we observed the daily interactions between Mr. Lee and the students. Consistent with previous literature (Grady, Dolan, & Glasson, 2010; Myers & Thompson, 2009; Scales, Terry, & Torres, 2009), Mr. Lee made it clear that a better grasp of scientific principles would improve his ability to integrate science at a higher cognitive level. When asked how confident he was with abstract science concepts taught in high school, Mr. Lee shared, “I feel a little intimidated when I am around the science educators” (388:389). “I ought to spend a day or two with the science teachers, especially if they are going to be teaching concepts I am going to teach. I should go and see exactly what they are teaching” (53:56), and “A better understanding of abstract science concepts would improve my teaching” (718:719).

What was unique about Mr. Lee is that his natural curiosity, coupled with his decision to make science a priority, motivated him to constantly improve his science knowledge.

I had a student ask me one time...what actually makes a red oak turn red and why does sweet gum turn yellow. I didn't know, but turned to the Internet. I went to the Internet and within minutes I knew why. You know, it quits producing chlorophyll and starts producing xanthophyll or other pigments. I didn't know that before and now I teach that better. (154:160)

Mr. Lee was constantly sharing questions, recently found facts, and ideas for future experiments with us. His intrinsic motivation was responsible for the science content knowledge he had developed after graduating from the pre-service teacher preparation program. He believed

in learning science *with* his students. He shared, “I’m not a science expert right now, so I have to learn with the kids” (171:172). This attitude was critical for increasing the quality of science integration. In response to issue five, Mr. Lee was not equipped with adequate science knowledge during pre-service courses, but as described, he was able to build on his knowledge over time. Though this curiosity is beneficial, the red oak example also shed light on the next theme – the lack of true scientific inquiry present in his courses.

Lack of Scientific Inquiry

Though Mr. Lee instructed at a high level, there were gaps in terms of the *how* when it came to science inquiry. Mr. Lee was naturally curious, but in the red oak example given earlier, science educators astute in inquiry might ask, “Why was the student not looking up the answer to their own question?” We found ourselves asking the same question. Mr. Lee was aware of his lack of science content knowledge but was not aware of the lack of inquiry techniques present in his lesson delivery, science projects, and greenhouse activities. Mr. Lee understood the value of creating relevant experiences that led to inquiry-based questions, and he understood the scientific method. Mr. Lee shared:

I think what I am doing is a totally different approach to science. When we begin discussing the scientific method, they remember talking about it in middle school science, but the experiments they are doing involve going through a list of steps to do in order to get an outcome. We are doing this to find out if there is a perfect way to fertilize these [Gerber daisies] and get them ready in time for the plant sale. (741:754).

Mr. Lee had created a phenomenal setup to an inquiry-based, relevant investigation but would later fail to allow students to create and execute their own experiments, including recording data, drawing conclusions, and sharing conclusions with their peers as inquiry-based learning prescribes (Llewellyn, 2005). Mr. Lee followed the setup of the daisy project with a highly structured, teacher-directed, learning experience. Students conducted *his* experiment, collected data as he prescribed, reported the data to Mr. Lee, who entered it into a spreadsheet, and then interpreted the data for the students. Hours of very purposeful preparation led to a missed opportunity from an inquiry perspective as Mr. Lee maintained control over the experiments rather than allow students to discover and experiment independently.

When asked, “Mr. Lee, who designs the experiments?” he responded, “We [teachers] do.” (315:319). “Every one of the experiments, at this point, have been my ideas, and then we setup the experiment – the student and I” (332:333). We asked, “What if students aren’t interested in Gerbers?” and Mr. Lee responded, “Well it doesn’t matter. They have to do it. They don’t have a choice.” (790:794). As Mr. Lee proudly highlighted each of the science fair projects around the room, it became clear that each project was a result of his curiosity and design rather than the students’. Competition repeatedly arose as an important component of the projects.

One student is going to use his Gerbers for his agriscience project, another is working with a veterinarian to test bull semen, and another is incubating some eggs. We’re trying to get students in different categories so we’re not all competing against each other. (660:666)

As depicted in the *actual* model of integration in this case (see Figure 2), award structures played an important role in directing the curriculum and integration.

Though the agriscience fair competition motivated students and Mr. Lee to participate, it impeded true inquiry in many instances. The profession encourages a happy marriage of competition and learning, but is that competition providing motivation for high level scientific inquiry? In this case, our conclusion was no. Though Mr. Lee demonstrated many elements of inquiry, student interest and control were missing.

Dig Around in the Curriculum

Mr. Lee shared that “I think all the science is in agriculture but sometimes we just have to dig around and do a better job of presenting it to students as science” (144:145). This captures the essence of this theme, which was a prominent and re-emerging concept. “What I was doing was taking the basic principles I use to teach and just using more scientific terminology with it and learning a little bit more about what makes that topic tic” (24:26). Mr. Lee gave an example, “If I was teaching fertilizer application and covering nitrogen, phosphorous and potassium, I could include parts per million in our measurements and make that an expectation while working in the greenhouse” (37:40). He explained that he constantly asks himself, “What would the science department do?” and then digs around the curriculum to find where those concepts exist. Mr. Lee believes that “every agricultural teacher is doing it but they just don’t realize it. You wouldn’t have to dig very deep to throw in a few science terms and concepts” (122:126).

Mr. Lee believes his conceptualization of how science fits into the traditional agricultural education program is logical and natural. He is adamant that agricultural education must, and can, stay true to the purpose of the program while *supporting* science instruction. Mr. Lee explained that he pursued the botany science credit for students in his horticulture class because the credit naturally fit the agricultural concepts he taught. He explained that he had control over what was taught and had the opportunity to create his own assessment for credit. We asked, “What happens when the state creates an end of instruction exam that changes the intent of botany in a way that doesn’t fit the agricultural class you currently offer?” Mr. Lee shared:

“It would change the game significantly. If what they are testing has no practical application to my agricultural class, then that will discourage me from offering that course. I tell everyone I’m glad I’m an ag. teacher and not a science teacher because a science teacher is forced to do certain things in a certain order for their end of course assessment. I’m not going to like that.” (648:666)

Mr. Lee made it clear that science has to work for him and he is not comfortable changing his identity from agricultural educator to science teacher. He finds value in *supporting* science instruction but feels that being the *provider* of science potentially changes the purpose and value of the program. Mr. Lee’s perspective is best depicted in a story he shared during one of the interviews:

One of my boys, who placed third in the district extemporaneous public speaking contest, talked about his purple fountain grass experiment in his speech. It was almost a flash of genius – and he is not a genius – but he was able to connect the dots between his drawn topic and the experiment. So my philosophy would be that kids ought to be able to explain what they are doing and throw some science in there themselves because that is what we are trying to emphasize to them. (92:100)

Science is inherent in the curriculum; it just has to be drawn out and capitalized upon.

Collaboration

Consistent with the literature, Mr. Lee struggled to find opportunities for collaboration with other teachers. The main barriers to collaboration were a lack of time and a sense of ownership in regard to agricultural and science facilities. Mr. Lee explained “I think I am using the same terminology and covering the same ground as the science department when I am out in the greenhouse but I don’t know that for sure. I know more collaboration should be happening” (56:59). When asked about barriers to collaboration, he explained “Time – being able to manage my time better and picking a time where I can shut down and go over there (science classroom)” (65:68). Inherent in his response is the idea that the two groups are located in different buildings

and collaboration requires traveling to a different location. While at the site, it was noted that the agriculture building was detached both physically and socially from the main school building.

In terms of sharing supplies and facilities, Mr. Lee said, “We haven’t come to the point where they (biology teachers) are bringing classes out to the greenhouse. I’ve offered it, but they just haven’t” (423:424). He continued to explain that he can only offer his facilities during certain times of year because of the plant sale and student projects that fill the greenhouse. There seemed to be territorial tension in regard to sharing equipment, and the distance between classrooms added to the challenges of collaboration. The expressed desire to collaborate was obvious, but actual examples of collaboration were few.

Student Science Achievement

Mr. Lee saw himself as an integral partner in helping students pass standardized science exams. Each August, the school reviews testing reports and identifies areas that students need to improve. After reviewing the data, he finds areas in his curriculum that can support those areas. Mr. Lee said:

ACT tests are a good example. When our students sit down to take that ACT test, maybe it doesn’t have anything to do with fountain grass but maybe it does have something to do with measuring in parts per million. They might remember the fertilizer measurements within the fountain grass experiments in parts per million and get one more question right. (113:119)

In addition to supporting standardized testing achievement, Mr. Lee also provided us data from the end of course assessments for the botany classes he taught in 2011, which noted an average 20% increase (average of 6 point gain out of 30) for those enrolled. Most importantly, Mr. Lee was interested in science achievement. The school expects that he play an educational role in increasing science achievement, and he has created specific objectives and assessments for his botany classes that provide feedback in regard to his effectiveness as a teacher.

Dual Purpose Agricultural Education Model

This final assertion is an attempt to synthesize the case study findings through the presentation of an *actual* content/context model of the Franklin High School agricultural education program as called for by Roberts and Ball in 2009. It is important to note this is not the presentation of a new conceptual model, but rather the depiction of reality in this unique case.

During an interview on the second full day at the site, Mr. Lee explained his general philosophy that drove the agricultural education department. When asked if he was more content or context focused, Mr. Lee responded, “both – I’m thinking content and context are buddies” (181:191). As Mr. Lee described his philosophy, and we observed the program in action, it became very clear that the Franklin High School agricultural education program subscribed *philosophically* to the dual-purpose model proposed by Roberts and Ball in 2009 (see Figure 1). As a result of this emergent conceptual base, Mr. Lee was shown the dual-purpose model and his response closely mirrored the assertion of Roberts and Ball (2009) – a strong connection to the model anecdotally, but a lack of full adjustment to reflect the blended content/context approach. The push for a dual-purpose model was a result of pressures by both the state government and local school board to more fully integrate core science concepts (Balschweid & Thompson, 2002; Roberts & Ball, 2009). Mr. Lee explained that “it wasn’t the science awards that prompted this change; it was necessary to find some added value to our coursework to ensure that we kept the two teacher program. [Cutting the second teacher] would affect the students and the program” (344:350).

Our analysis led us to the question, “How does this case deviate from the philosophical ideal proposed by Roberts and Ball in 2009?” Though Mr. Lee subscribed to the dual-purpose

approach proposed by Roberts and Ball (2009) *philosophically*, in reality, integration occurred in a more segmented fashion (see Figure 2). Photographs of textbooks revealed two major types of books: 1) production agriculture practices and, 2) agriscience. Books titled *Welding and Livestock & Poultry Production* were in the more content-focused classroom while *The Science of Agriculture* was in the more contextual classroom. Students were observed in the agricultural education laboratory wiring electrical circuits less than ten feet from another student collecting data on plants involved with a fertilization experiment. The dual model was evident in the design of the building. One large classroom was divided into two smaller classrooms – one devoted to production agriculture principles and the other was dedicated to teaching science principles. Additionally, the influence of the award and contest structures, as mentioned earlier, was woven into all instructional design. Mr. Lee shared, “my whole preparation is geared towards contests and FFA experience, and I just think that is what makes me a totally different animal from our science teachers” (733:734). This award structure was such a strong driving

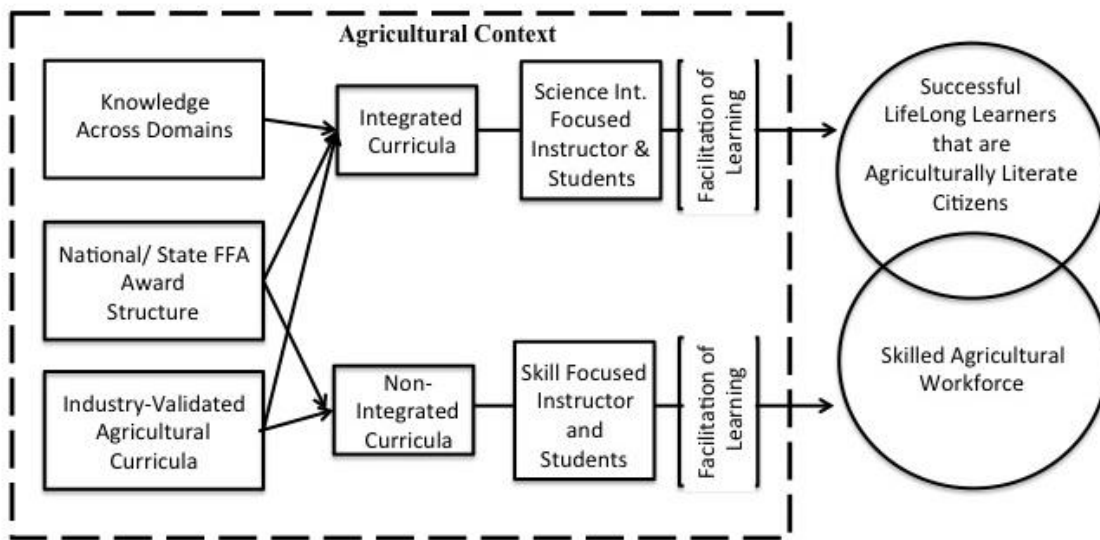


Figure 2. Franklin High School conceptual model for agricultural subject matter as a content and context for teaching. Adapted from “Secondary Agricultural Science as Content and Context for Teaching,” by T. G. Roberts, and A. L. Ball, 2009, *Journal of Agricultural Education*, 50, p. 87.

force that it was added to the *actual* conceptual model as one additional source of content. As depicted in Figure 2, the curriculum was driven by three factors: a) knowledge across domains, b) industry-validated agricultural curricula, and c) the state and national FFA award structure. Two of the knowledge bases, industry-validated curricula and knowledge across domains, were aligned to the specific segmented track at Franklin High School – a deviation from the original conceptual model. The third added knowledge base, the award structure, was the primary driving force for both the content and context tracks. Instruction followed in one of either two tracts – a highly integrated science path or an agricultural skill based path. Mr. Lee explained that, “students can come to our department and choose to follow a rigorous science-heavy course, but there is the option to take a very production focused animal science course that didn’t involve science credit” (123:128). As depicted in the Franklin High School conceptual model, there seemed to be two instructors specializing in either agricultural skill development or science integration. Though integration was present, it existed in one segmented section of the program rather than full integration. This sentiment addressed issues one and two and was evident in all

aspects of the program. Assertions and conclusions are summarized in Table 1 as well as how they were resolved.

Table 1

Key issues and resolution

Issue	Resolution
Issue 1: Was science integrated effectively?	There was a strong presence of science integration in this exemplary case. However, this integration occurred in only one of the two tracks offered and was purposefully extracted from the skill based track.
Issue 2: How was agriculture content maintained?	Mr. Lee focused on digging into the agricultural curriculum for the embedded science that already exists. Agricultural content drove the context for core areas, not the opposite.
Issue 3: Was inquiry effectively demonstrated?	Mr. Lee exhibited a strong desire to present inquiry-based lessons; however, many elements of the inquiry process were weak or missing. Student interest did not drive the experiments, and they were mostly teacher-directed.
Issue 4: How was science knowledge strengthened?	Mr. Lee conceded that his science knowledge was a weakness. However, that weakness was overcome through a personal commitment to learn <i>with</i> the students and constant curiosity of science concepts.
Issue 5: What role did collaboration play?	Though collaboration was valued and desired, it rarely occurred. Barriers included a lack of time, territorial sentiments over resources, proximity to the main campus, and the demands of an FFA Advisor.

Discussion and Praxis

The agricultural education program at Franklin High School illustrates how science integration does not require advanced facilities, large budgets, urban environments, or abnormal community pressures to be successful. Science integration can occur in what may appear as a very traditional agricultural education program. This ideal is represented well by the dual-purpose conceptual model of agricultural education put forth by Roberts and Ball (2009). Though the actual model was more segmented in this case, the dual-purpose model requires core concepts, like science, to be integrated in addition to traditional vocational aspects of the program. This case study highlighted a successful dual-purpose model; however, the required inquiry-based pedagogy skill sets were lacking. In order for science integration with inquiry-based pedagogical techniques to succeed, pre-service teachers should be trained and supported in how to teach both agricultural and STEM content subjects concurrently.

Congruent with the warning from Scales, Terry, and Torres (2009), agricultural education should carefully consider the implications of rewarding science credit for agricultural classes. If current agricultural education classes naturally align with a science course for credit, science credit could be warranted. However, agricultural educators must recognize that with the inclusion of core science courses like biology comes increased accountability and daily teaching requirements. Agricultural educators should determine if accountability requirements for science

credit would detract from the aspects of agricultural education programs that make them fun and attractive to students. Future research comparing the effectiveness delivering core science content, like biology, between agricultural educators and science teachers would help answer that question.

A lack of science content knowledge has been found to be a barrier to science integration (Myers & Thompson, 2009; Myers, Thoron, & Thompson, 2009; Scales, Terry, & Torres, 2009). These authors called for undergraduates to enhance their science coursework. We believe that the issue is more complex. This case presented a unique interpretative analysis in terms of intrinsic motivation to learn science. Though not a lens identified prior to entry into the case, Ajzen's (1991) theory of planned behavior emerged as we described the lack of science content knowledge. Ajzen's (1991) theory of planned behavior describes that behavioral, normative, and control beliefs drive an individual's intention to act. There is usually a normative pressure to integrate science, but what if agricultural educators are more interested in agriculture than science? Their behavioral and control beliefs may hinder the intention to integrate science unless more science is required in their pre-service curriculum. Mr. Lee's intrinsic motivation to learn science was the driving force in his attention to science integration. How do we foster such motivation within future educators? Teacher recruitment efforts should focus on individuals attracted to science in the context of agriculture rather than those only interested in agriculture.

In terms of scientific inquiry, this case yielded very similar results to that of the case examined by Grady, Dolan, and Glasson (2010) – a lack of inquiry and an adherence to a somewhat strict, teacher-directed learning experience. Mr. Lee was sincerely interested in inquiry but failed to execute it effectively. As such, it is critical that both pre-service and in-service professional development be conducted that focuses on scientific inquiry and the pedagogical principles that support it. The role of various competitions like the agriscience fair must also be carefully evaluated to ensure they support, and don't impede, the overall goal of agricultural education. Though there are many advantages to providing opportunities for competition, there are potential drawbacks, such as a lack of student interest and control, as made evident in this case. Career development events, whose purpose is to promote science integration, must be carefully crafted to reward the desired behaviors and not distract from student-led inquiry process.

Stone, Alfeld, and Pearson (2008), and Parr, Edwards, and Leising (2006) described that math already exists in the curricula of career and technical education. The task of the educator is to interrogate the curriculum by drawing out the math concepts and capitalizing on those throughout the lesson. Mr. Lee described this same principle but called it "digging." Teacher education programs can support this process by practicing the skill of "digging" or probing the curriculum in order to draw awareness to the abstract science concepts. In short, teachers don't need to change the curriculum; rather, they must become more aware of the science embedded in it. In addition, school systems and science departments should be more transparent with the agricultural education departments regarding key science concepts that need additional attention or that may be included in standardized tests.

(Closing vignette) When asked what is next, Mr. Lee shared that he hopes to continue to grow and enhance the integration of science in his program. He explained that, "I will always be looking for ways to incorporate science into the program so long as it doesn't change the real purpose of what we're doing here at Franklin. The science is already in our program; my job is to simply find it and capitalize on it. Agriculture drives the science—science doesn't drive the agriculture. It is my hope that students with all kinds of career goals can find a home here. Some will be involved in agriculture; some will not. Hopefully all will leave as life-long learners regardless." Unfortunately, Mr. Lee has since left Franklin High School for private industry leaving many wondering what motivated his departure from the classroom.

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