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Radio Frequency Learning Module

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Radio Frequency Learning Module

In partial fulfillment of the requirements for the

Degree of Master of Science in Technology

Erin S. Weir

A Directed Project Report

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Abstract

As technology constantly moves forward in its innovative ways to manage inventory in the supply chain, barcodes are becoming a technology of yesterday. Furthermore, Radio Frequency Identification (RFID) has secured its spot in the supply chain management, inventory control, as well as the manufacturing industries. Similar to any emerging technology, the high start up costs prevented widely applicable use of the technology. The lower manufacturing cost of the materials used to manufacture the equipment housed in a RFID system are making RFID a realistic alternative to many supply chain dilemmas.

This project develops educational materials for use in an undergraduate Industrial Distribution class and highlights an introduction to RFID, a recorded lecture, as well as a laboratory experiments used to reinforce the basic concepts of RFID.

Introduction

New technological advances are making automatic identification (auto-ID) an essential tool in the supply chain industry. Historically inventory was taken with pen and paper. Technological advances gave way to barcodes. Barcodes require a line of sight and still incorporate the heavy amount of man power needed to scan the inventory barcode. Technology has developed a way to account for inventory throughout the supply chain, from the manufacturer to the warehouse, to distribution centers, even to the end use customer; this technology is called Radio Frequency Identification (RFID). Weis (2003) believes it's possible to have every man-made object labeled with a unique tag associated with a digital entity. This digital data could provide detailed information such as the manufacturing date and time as well as the personnel responsible for assembling the entity. These possibilities and more are all possible with RFID.

Statement of the Problem

The Industrial Technology department at Purdue University has a responsibility of properly preparing its students for the industrial workforce through educational curriculum and technical lab experiments. The Supply Chain Management Technology Laboratory has radio frequency identification software and technology, which gives the Industrial Technology department the opportunity to prepare their students with realistic technical exposure. Students are graduating from the Industrial Technology and Industrial Distribution degree programs without the basic knowledge and skill set to interface with the radio frequency identification software and technology located in the Supply Chain Management Technology Laboratory (Knoy B044). Radio Frequency Identification (RFID) has grown in its popularity in industrial use as explained in an *RFID Journal* article, "The growth opportunity for the RFID market is estimated to be $9.7 billion today, and is expected to exceed $14.8 billion by 2009" (Bacheldor, 2006). Instructors teaching the radio frequency identification software lack the necessary instructional tools to aid them in interfacing the students with the radio frequency identification software and technology. Students in the Industrial Technology Department have not gained the technical depth involving RFID which threatens the stability of graduating students' knowledge base as they enter the industrial workforce. The Department of Industrial Technology needs to create a learning module to be used in the instruction of the radio frequency identification technology. The creation of this learning module will start to bridge the gap between the technology and the students.

Significance of Problem

Industry leaders believe that as student graduates from Purdue University they are graduating equipped with the knowledge and tools in order to successful integrate with the mainstream. Students graduating from the College of Technology at Purdue University are expected to have real, hands-on, technical education established through lectured seminars coupled with lab exercises. Radio frequency identification (RFID) is growing in popularity and its usage. It is important that the students graduating from the Industrial Distribution program be well equipped with the knowledge of the RFID and its impact in industrial usage. The industrial advisory board, one of the project stakeholders, has established a commitment with the department to help identify skills and attributes that students need to have acquired through their academic experience that will make the students more marketable and successful in the workforce. The industrial advisory board identified RFID knowledge as a key skill that would make the students more marketable, and RFID training will increase the student's working knowledge of RFID.

Statement of Purpose

The purpose of this project was to develop the educational materials to enhance the working knowledge of Radio Frequency Identification (RFID) within the Industrial Technology department through online lectures in Adobe Connect, to demonstrated mastery with quizzes, and finally a laboratory experiment to be carried out following the recorded lecture. This sequence of events ensures that students have knowledge of RFID technology.

Definitions

Hz: Hertz is the measuring unit for frequency. It is the cycles per second of a given frequency (Herrick & Thomson, 2003)

MHz: Mega Hertz is the measuring unit for frequency that is equivalent to 1×10^6 (Herrick & Thomson, 2003)

kHz: Kila Hertz is the measuring unit for frequency that is equivalent to 1×10^3 (Herrick & Thomson, 2003)

λ : wavelength (Herrick & Thomson, 2003)

c: (in reference to the wavelength calculation) the speed of light 3×10^8 m/s (Herrick & Thomson, 2003)

v: operating frequency (in reference to calculating near field communication) is the frequency that the RFID system is transmitting data/information represented by the lower case Greek letter “nu”. (Herrick & Thomson, 2003)

f: frequency is the amount of reoccurring events in a given period of time. (Herrick & Thomson, 2003)

ADDIE: Similar to the ASSURE model, the ADDIE model is an instructional design model the represents the following: “analyze, design, development, implement, evaluation” (Heininch, Molenda, Russell & Smaldina, 1996)

Amplitude shift keying (ASK): the process of represents digital data and information as a variation in the amplitude of the peak (Weis, 2003)

ASSURE: Instructional design model that requires the following steps: “analyze learners, state objectives, select media and materials, utilize materials, require learner participation, evaluation/review” (Heininch, Molenda, Russell & Smaldina, 1996)

Asynchronous e-learning: “Makes it possible for learners to log on to an e-learning environment at any time and download documents, facilitate discussions, send messages to teacher or peers.” (Haythronthwaite, 2002) Generally thought of as more thought provoking.

Distance Education: demonstrated change in behavior from remotely accessed material and instruction (Capper, 2001).

Instructional Design: providing a conceptualized framework from which a communication tool will be used to visualize, direct, and manage processes for future guided learning. (Gustafon & Branch, 1997)

RFID: Radio Frequency Identification (Herrick & Thomson, 2003)

Synchronous e-learning: “supported by media such as videoconferencing and chat, has the potential to support e-learners in the development of learning communities. Learners and teachers experience synchronous e-learning as more social and avoid frustration by asking and answering questions in real time” (Hrastinski, 2007)

Assumptions

For this study, it was assumed that students have basic working knowledge of Adobe Connect, Go Meet software, internet explorer as well as Microsoft Word and Microsoft PowerPoint. It is assumed that the Supply Chain Management Laboratory, which is located in room B044, Knoy Hall on the Purdue University West Lafayette campus, will have the updated Alien Technology.

The study has been conducted using students enrolled in the *Purchasing, Inventory, and Warehouse Management* course (IT332) at Purdue University. It is assumed that these students have successfully completed the prerequisite *Industrial Supply Chain Management* (IT 230) course.

Delimitations

Students must be Purdue University students in order for them to have access to the technology. The RFID Alien technology in the Supply Chain Management Technology Laboratory is will be used. For this project, time was a limitation as it restricted the scope of the project because there was not time to evaluate the usefulness of the lecture material presented to the students.

Limitations

This study was limited by the lack of students to give critical feedback pertaining to the Adobe Connect recorded lecture. There was additional RFID technology installed in Knoy B044 during the process of completing this project that has not been included in the laboratory experiment. Additionally, the Alien Software is housed only in one computer in Knoy B044.

Literature Review

The literature review serves as a compilation of researched articles pertaining to the subject of instructional design, adult learning, radio frequency identification technology, as well as distance education in order to ensure that this research topic and area will be relevant, insightful, as well as meaningful. The review in the following section will chronicle studies, literature, and journal publication previously conducted on curriculum development, radio frequency identification technology, and distance education.

Business technology search engines supplied by collegiate subscriptions provided much of the text pertaining to the managerial processes involved in properly maintaining and executing the use of radio frequency identification. Engineering technology search engines were used in order to find the scientific usage rates, specifications, and limitations of the technology. Key words used in conjunction with the obvious radio frequency identification included: *industry usage*, *instructional processes*, *adult learning*, *instructional design*, as well as *distance education.* Educational search engines provide literature relevant to *adult learning methods and styles*. Once material found in a specific search was continually found in others, it was assumed that adequate information was discovered on the topic.

Distance Education and E-learning

There are obvious advantages for incorporating technology in distance education. Bouhnik and Marcus (2006) describe some advantages as the freedom to decide the schedule of when online lesson will be learned, the lack of dependence on the time constraints of the lecturer, freedom to express thoughts and ask questions without limitations, and the accessibility to the course's online materials at a student's own election. Capper (2001) describes the benefits of e-learning as the ability to access the learning program at any time, the fact that participants do not have to physically meet, interactions and discussion are more succinct, the fostering of group collaboration, and the new educational approaches that are presented to teachers as well as students. Online educational arenas also provide multiple interactive opportunities with other learners, educators, and content. Asynchronous communication facilitates learning anywhere any time. It also creates learning communities at local, national or global levels expanding a student's "global awareness". Enables learning privately that allows that communication to move to a dialogue to create a shared understanding of meaningful content through "comparing, contrasting, and/or combing similar information collected in dissimilar locations" (Harris, 1999). Riel (1996) stated that the partnerships and interactions between people who gather online that define community, not the digital technology that is used.

The benefits of distance education are not without its opportunities for improvements. There is a lack of framework to encourage students to learn, an absence of a learning atmosphere, and the learning experience is less efficient (Bouhnik & Marcus, 2006). Martin (2005) states that, "…the difficulty to sustain interest of the remote learner, lack of specific training and guidance for teachers, and concerns about the robustness and cost of the technology." Dutton and Perry (2002) believe e-learning is not an effective medium to facilitate learning because of the lack of self-discipline or sense self-direction. Harris (2000) claimed that online collaboration can fail for three reasons: context, planning, and logistics. Harris argues that the context of the online collaboration needs to be curriculum-based as opposed to being technology based. The contextual downfall can be avoided by, "articulating specific goals, specific task, and specific outcomes (Rogers, Andres, Jacks, & Clauset, 1990)." Secondly, online collaborative learning can fail because of planning—or the lack thereof. This obstacle can be overcome by carefully planning the combination of factors that with the subject matter, technology mediation tools, and the nature of the activities in which the students will participate being mindful that rigid constraints can hinder students' learning (Lopez-Ortiz & Lin, 2005). Finally, according to Harris (2000) online collaborative learning can fail because of logistics. Logistics refers to the coordinating schedules of those facilitating the online course as well as setting timelines. This challenge can be overcome by proactive curriculum planning (Harris, 2000).

Technology in Education

Technology is constantly changing; the need for technology is dependent on the perceived importance of the technology itself. Lock and Redmond (2006) believe in the importance of technology in education stating that technology gives the ability to "utilize technology in education enables learning to expand beyond the walls of the classroom to create authentic learning relationships with others who are at a geographic distance". The purposes of technology-based collaboration are to create real world environments that employee the context in which learning is relevant, and to focus on realistic approaches to solving real-world problems (Chen, Benton, Cicatelli & Yee, 2004). Technology applies a current knowledge of sorts for some useful purpose (Hooper & Rieber, 1995).

Technology has continued to change, but the classroom instruction has not (Cuban, 1993; Office of Technology Assessment (OTA), 1995; Tobin & Dawson, 1992). Hooper and Rieber (1995) gives the analogy of a doctor and/or dentist 50 years ago would not be competent and capable enough to practice with the technology of today; but if a teacher from 50 years ago would feel comfortable conducting classroom instruction in most of today's classrooms because most technologies and innovations introduced are not being adequately used; proving that technology's importance in education. The OTA (1995) and Hativa and Lesgold (1996) believe that educators' definition of technology integration has evolved from teaching technical definitions to teaching sound technical theories, but teachers' actual technology integration usage has seen little change.

What role should technology play in education? Many researchers believe technology is an integral part of today's education (Ertmer, 1999; Thornburg, 1997). Salomon (1991) believes that technology in education, "…carries with it a renewed conception of instruction that shifts attention from instruction as the imparting of knowledge to instruction as the guidance of socially-based exploration in intellectually rich settings." Technology's versatility, accessibility, and its use in education may help to shift the foci from "knowledge-as-possession" to "knowledge-as-construction"; moving learning from outside-guided to learning as self-guided (Ertmer, 1999). The idea of computers as an effective way to develop higher-order thinking skills, including defining problems, judging information, solving problems, and drawing appropriate conclusions is supported by Laney (1990); but the study conducted lacks numerical significance, furthermore there is not logical connection between the methodology and the study results. The belief that computer-supported education environments should not involve the knowledge and intelligence to guide and structure learning processes, but should create situations and offer tools that stimulate students to make maximum use of their own cognitive potential is agreed upon by Tam (2000) and Scardamalia et al. (1989).

Adult Learning

Knowles (1980, 1990) studies suggested that as people mature, their self-concept moves from being dependent to being self-directing. An adults' experience is an asset for learning. Their readiness to learn is closely connected to social roles; they are interested in immediate application of knowledge, and are motivated to learn by intrinsic factors (Knowles, 1980, 1990).

Spitler (2005) agrees with the concept of Knowles (1980, 1990) that learning style is connected to social roles of adult learning styles stating, "…users rely on a social support mechanisms and networks to improve their fluency of technological applications p17." Learning to use technology alone can be difficult, but when different aspects and utilization are expected from an individual, learning can become even more difficult. Having many people who currently use technology with limited understanding of the tool proves to be a downfall for corporations everywhere (Spitler). Although the article attested to learning difficulties encountered by many, the study that was conducted lacked large sample sizes and at the same time attempted to quantify attitudes, behaviors, and learning curves. Spitler's study is disputed among experts due to its experimental constructive problems that measuring qualitative data with quantifiable indicators presents to the impact of the study. Furthermore, multiple analyses were made from the same sample data with a lack proof of additional data collection conducted. Confirming the idea of instructor interaction being more beneficial is that students were forced to seek additional help in order to acquire the skill taught by specific lessons when the student relied on a reference manual (MacLeod & Morrison, 1998). Although the results of this study was clearly examined and explained, there was a lack of procedural clarity. In addition, because the interaction of the administrator of the experiment and the participants were not scripted nor limited, the introduction of biases is possible.

Former research in learning methods and styles still are referenced as a point-of-interest, proving the validity of the experimental research conducted decades earlier such as Kolb's learning style research conducted in 1980. Kolb (1980) suggested that preferred learning abilities will draw learners to particular subject studies that play to specific learning strengths and in which relative success if found and enjoyed. Ailisto, Korhonen, Pohjanheimo, Strömmer, and Välkkynen (2006) understood that covering the course material several times using different methods proved to be more useful than just covering the material used in one particular method. Deterline (1988) resolved that it is essential to include user needs when documentation is written, because much software documentation is written by subject matter experts, and often times non-experts cannot fully comprehend topics introduced. Deterline's argument closely aligns with Knowles (1980), both stating that technological interaction between the learner and application is essential to learning what is done, providing evidence for the argument that increased user interface time increases the learning application.

Learning Objectives

Benjamin S. Bloom, along with a group of measurement specialists from across the United States met twice a year in 1949 to discuss ideas and formats that could reduce the labor of preparing annual comprehensive examinations. From this series of meetings came a publication, *Taxonomy of Educational Objectives: The Classification of Educational Goals Handbook I: Cognitive Doman* (Bloom, Englehort, Furst, Hill & Krathwohl, 1956). Also, as a result is the popular Bloom's Taxonomy. The purpose of this taxonomy is a framework for classifying statements of what students are expected to learn as a result of instruction (Krathwohl, 2001). It's used as a way to facilitate the faculty at various universities in order to create banks of items, each measuring the same educational objective (Krathwohl, 2002). The taxonomy is broken down into six categories:

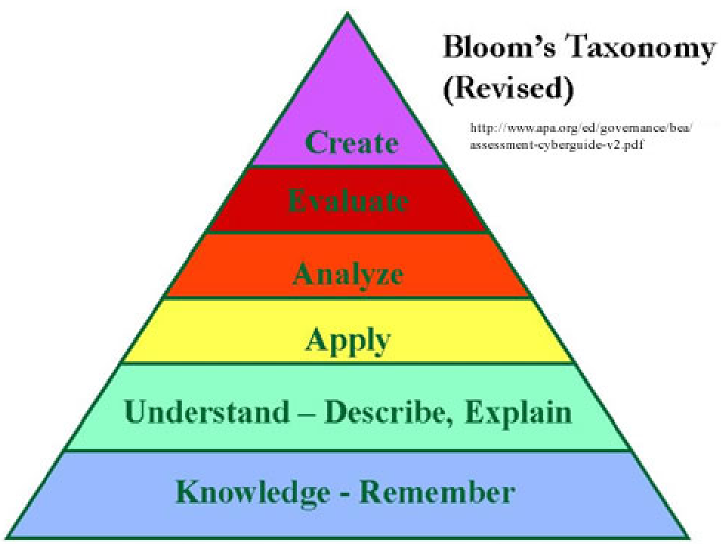

Figure 1. Bloom's Taxonomy newly revised (Anderson & Krathwohl, 2001). Taken from: http://uwf.edu/cutla/images/bloom_taxonomy.jpg

Forehand (2005) recognizing the six categories of Bloom's Taxonomy, revised as:

- "*Remembering* retrieving, recognizing, and/or recalling relevant knowledge"
- "*Understanding* constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining."
- "*Applying*: carrying out our using a procedure through executing, or implementing"
- "*Analyzing*: breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing."
- "*Evaluating*: making judgments based on criteria and standards through checking and critiquing."
- "*Creating*: putting elements together to forma a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing."

Bloom's Taxonomy (1956) can be used in a broad spectrum of application because of its ability to represent indication of altered terminal behavior as the student performs a variety of acts.

Instructional Design

Selecting a proper instruction design model is as important as selecting the curriculum development model. Instructional design (ID) has a history from the 1960's where Silvern attempted to apply a general systems theory in order to create an, "effective and efficient", aerospace and military training manual (Bertalanffy, 1968). Although instructional design's roots cannot be pinpointed, Gustafon and Branch (1997) defined instructional design as, "a system of procedures for developing education and training programs in a consistent and reliable fashion". ID can been seen as providing a conceptualized framework from which a communication tool will be used to visualize, direct, and manage processes for future guided learning.

There is a variety of instructional design models used to guide facilitation towards a diverse audience. Some instructional design models are geared towards adult learners, some towards adolescent learner, and others may be geared towards industrial training participants. The method of presentation varies within the models as well. A constant reoccurring theme in a majority of reputable models is the idea of the major five steps: analyze, design, develop, implement, and evaluate—the ADDIE model. The ADDIE model stands for "analyze, design, development, implement, evaluation (Heininch, Molenda, Russell & Smaldina, 1996). The ADDIE model represents the core principles behind any instruction design model. This loosely resembles the ASSURE model that stands for "analyze learners, state objectives, select media and materials, utilize materials, require learner participation, evaluation/review" (Heininch, Molenda, Russell & Smaldina, 1996).

A	**Analyze learners**
S	**S**tate objectives
S	**S**elect media & material
U	**U**tilize material
R	**R**equire Learner Participation
E	**E**valuation/review

*Figure 2.*Heininch, Molenda, Russell & Smaldina (1996) instructional design model, taken from: http://jbyun.com/isd/isd_Models/ISD_Model.html

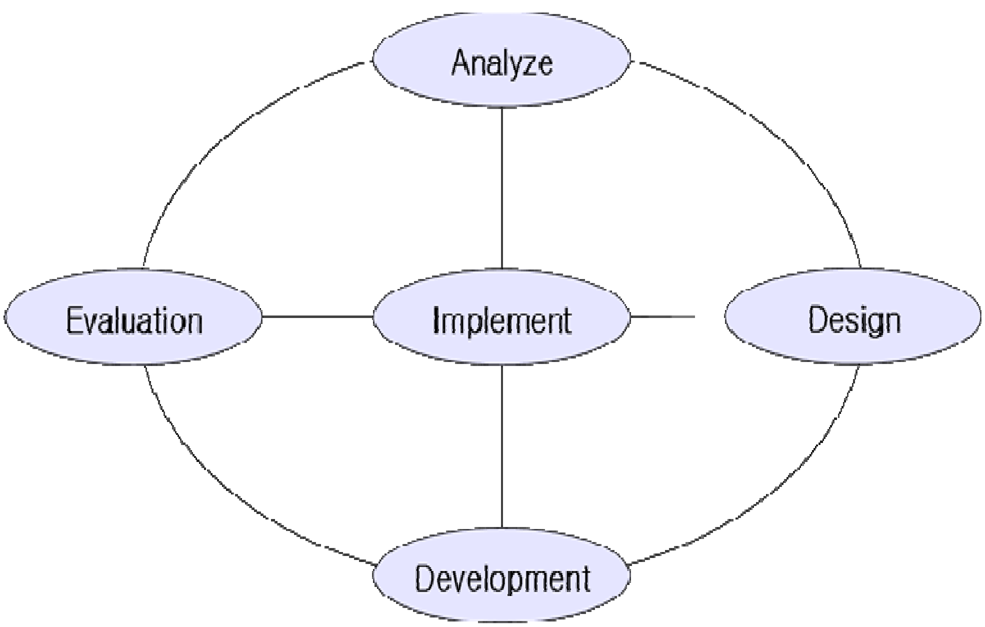

*Figure 3.*Gustafon and Branch (1997) instructional design model taken from: http://jbyun.com/isd/isd_Models/images/Core%20elements%20M.png

Gerlach and Ely (1980) created an instructional design model for the classroom with the assumption that the classroom teacher would be the developer of the instruction as well as the one held responsible for delivering the instruction. What is unique to the Gerlach and Ely model is the starting point of analyzing content and objectives instead of starting with the problem. The next step in this model is to identify the entering characteristics of students. Gustafson and Branch (1997) identified that the identification of student characteristics be followed by a, "simultaneous and interrelated decision on the strategies, grouping, space utilization, and allocation of time and resources." The evaluation portion sparks revision for the future instruction of the material. This is a more detailed model in comparison to the ADDIE or ASSURE model.

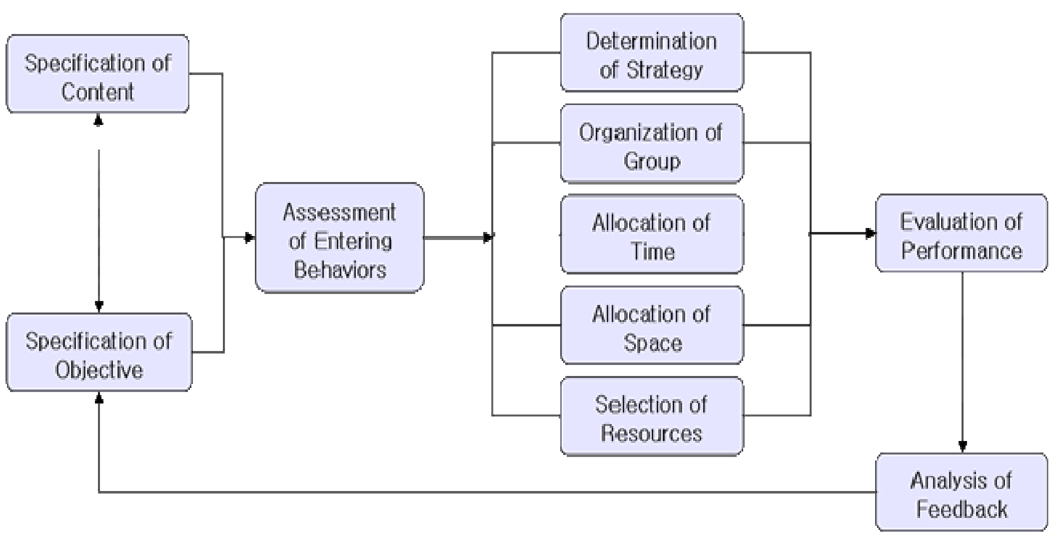

*Figure 4.*Gerlach and Ely (1980) instructional design model taken from:

http://jbyun.com/isd/isd_Models/images/gerlach%20M.png

Reiser and Dick's (1996) model is a simplistic and straightforward view of the instructional design model. The seven steps are a modified version of the Gustafon and Branch (1997) model. Unique to this model is the step used solely for the development of the assessment tools. Gerlach and Ely (1980) call for an evaluation of the performance. From which a feedback loop is enacted. For Reiser and Dick (1996) model, the development of the assessment tool being part of the instruction design forces one to think of the feedback prior to the implementation.

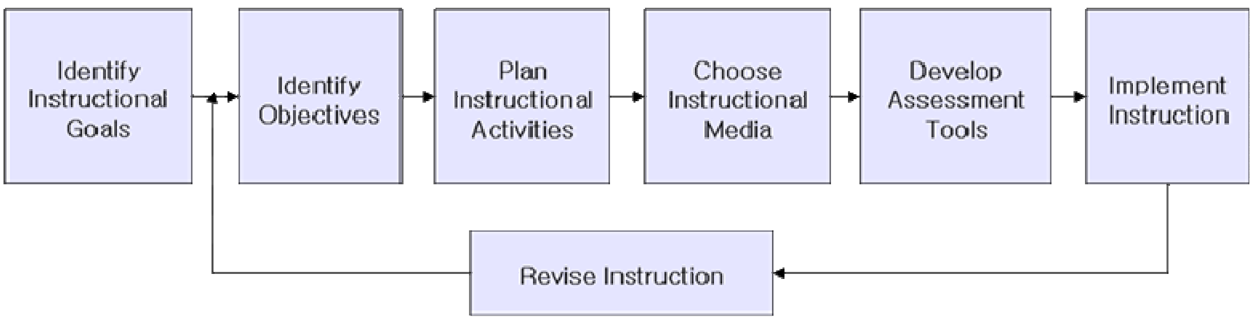

Figure 5. Reiser and Dick (1996) instructional design model taken from: http://jbyun.com/isd/isd_Models/images/Reiser.png

The Dick and Carey (1985) model is the most widely used and accepted instruction design model to date. Gustafon and Branch (1996) believe that its popularity is due to its very readable text, frequent updating, clear and simple examples for each step, and cases to provide readers with a frame of reference. Dick (1992) made small changes to its original model to reflect the large interest in performance technology, context analysis, multi-level evaluations models, and total quality management. Many (Branch & Gustafon, 1996; Gagne', Briggs & Wager, 1992; Dick & Carey, 1985) would argue that there are philosophical identities that need to be addressed in order for successful implementation of instructional design to occur. Those arguments are the following:

- "Learning is not completely deterministic or absolute, but structure and probabilistic outcomes are acceptable"
- "Classification of instructional design models should be based on contextual factors, learning expectations, and the type of desired knowledge or skill "
- "The greater the compatibility between the instructional design model and the contextual, theoretical, and philosophical origins, the greater the potential to generate effective instruction"
- "There will continue to be an interest in instructional design models, however, the level of specificity at which instructional design models are applied with change"
- "Instructional development modes serve as conceptual and communication tools for analyzing, designing, creating, and evaluating guided learning ranging from broad educational environments to narrow training applications"

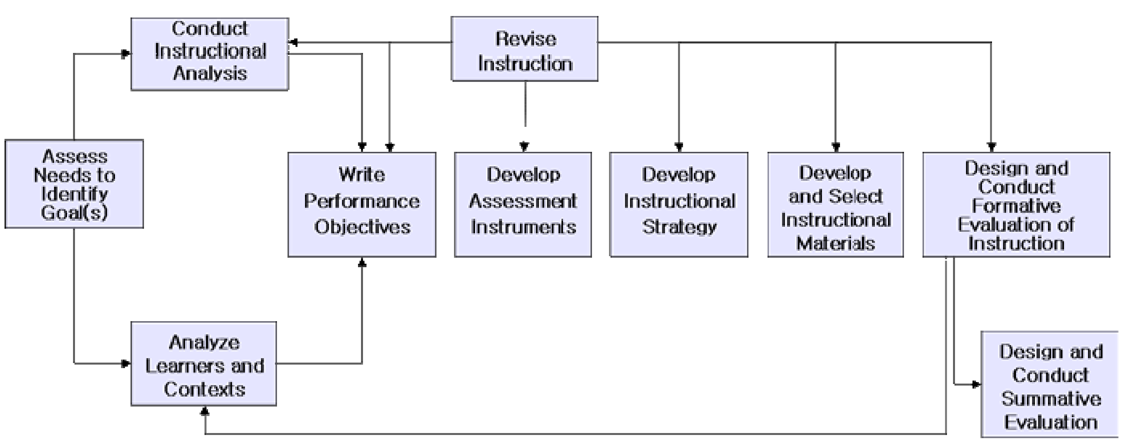

Figure 6. Dick and Carey model (1996) taken from:

http://jbyun.com/isd/isd_Models/images/dick%20M.png

The Instructional Development Institute model was created by the National Special Media Institute in 1971 and is similar to the Gerlach and Ely (1980) instructional design model where there is a step that is specifically for the evaluation of the target audience demographic. This will better help identify the needs of audience so that strides can be made toward successfully communicating the material. Also unique to this model is the identification of the need to organize tasks, responsibilities, time lines, and managers. Similarly, there is the reoccurring theme of ADDIE/ASSURE processes. This model is validated by successful workshops of 20,000 teachers. The various forms of media they used were: simulations, games, and group exercises. The major sections of this model are broken down into: define, develop, and evaluate. Associated with each step are three subsequent actions.

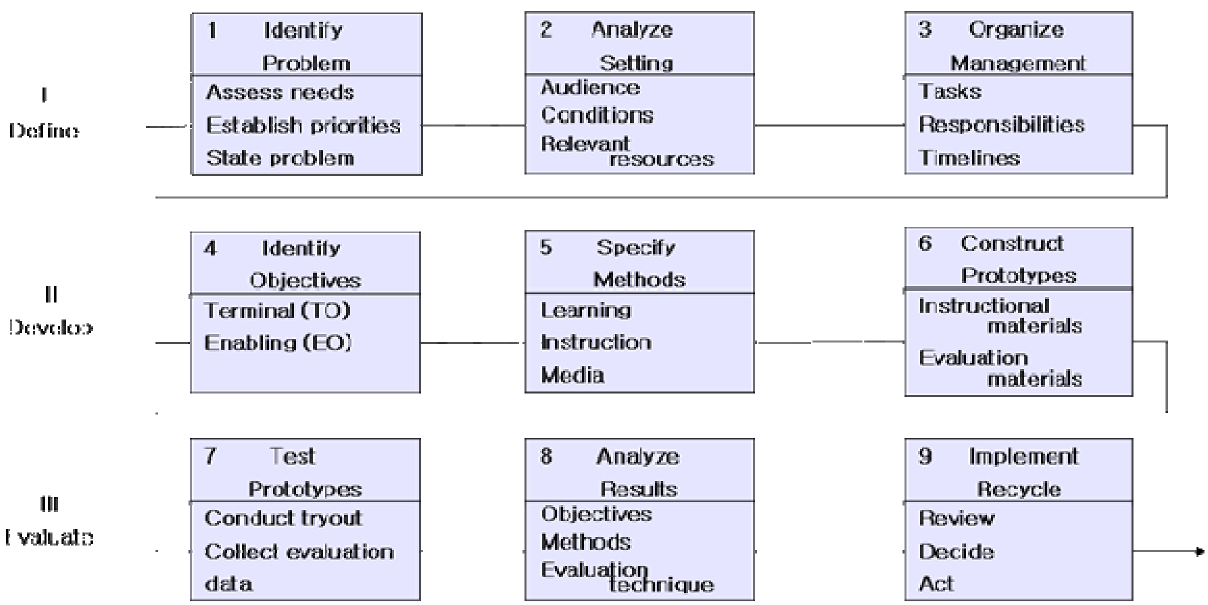

Figure 7. The Instructional Development Institute (IDI model) (National Special Media Institute, 1971) taken from: http://jbyun.com/isd/isd_Models/images/idi%20M.png

Within the “define” stage, there are three steps: identify the problem, analyze the setting, and organize management. When defining the instruction, it must begin with the problem. This is different from the Gerlach and Ely (1980) who started with the analysis of the content and objectives. The next step in both the Gerlach and Ely model as well as the Instructional Development Institute model is the evaluation of the audience. It is important that the targeted audience be taken into account because different students have different learning styles. It is equally as important that the instruction presented to the student be robust enough that one can gain insight while appealing to their particular learning style. The last step in the define stage is the organization of the management from tasks to responsibilities. Understanding who is held accountable for what is vital. It gives the instruction shape and should accentuate on the positives of a person’s strength.

The “develop” stage is where a majority of the work is done. First, the objectives are identified. What are the terminal objectives or the objective that will be the end results? Defining early what the terminal objectives are, has a great impact on the evaluation portion of the model. In addition, the enabling objective or those steps that will help reach the end goal also help in the formation of the evaluation. What small steps need to be clarified in order to reach a greater goal? Next in the develop stage is the method by which the instruction will be taught. Will there be a specific media that will be used over another? What learning style will a majority of the students use? Finally, this model calls for a small prototype. This prototype will include instructional materials to gain insight as to where the instruction could use improvement.

The last stage of the model is evaluation. Creating instruction without evaluation is like putting an airplane in the air without having maintenance performed. It is a slippery slope, by which the end goal can fail to reach is original target audience. Or even worse, none of the objectives declared in step one “define” will be met. The first step in the evaluative portion is to test the prototype. Next, the analysis of the results was completed. This test whether or not the objectives were met in addition to the evaluation technique is also evaluated. Finally, the data collected is reviewed, empowered with this information, the instructor can make an informed decision as to proceed forward with the material. For the purpose of this project, the ASSURE model was be used. The realistic relevance of this model lends itself to easy application.

Radio Frequency Identification

Radio frequency identification (RFID) works similarly to bar coding technology. Smith (2005) thinks of RFID as, “…a technology that captures data from an object without physical contact and possible wear and associated damage to bother reader and receiver.” While that definition is accurate, it loosely defines, and does not capture the full essence of what RFID is, nor it capabilities. El-Misalami and Jaselskis (2003) depicted the technology as, “A branch of automatic identification technologies in which radio frequencies are used to capture and transmit data. Radio frequency identification technology involves the use of tags, or transponders, that can collect data and manage it in a portable, changeable database within the tag; communicate routing instructions another control requirements to equipment; and which can withstand harsh environments.” This definition holds truer to the technology. Although, many definitions explored in the literature talk about the automatic identification of the technology, very little give precedence to the back end of the technology, the information technology system/database management systems. This technology was introduced in World War II in1948, in order to track high priced assets such as arsenal defense weapons, radio frequency identification has been around for a lengthy amount of time, but its recent unforeseen popularity in the supply chain can be attributed to its multi-faceted purpose.

The use of the technology has great potential to revolutionize the way tracking, maintenance, material management, engineering, and design (Jaselskis & El-Misalami, 2003). An RFID system can be broken down in a simplistic manner of three parts: a tag, reader, and data processing system. The tag is a small device that carries electronic data. It can also be known as a transponder. The tag is attached to the item in which identification is being sought. Next, the reader (or scanner) communicates with the tag by using radio frequency signals. Finally, the data processing system contains the information on the identifiable object, and can distribute the information remotely to other data processing systems (Keskilammi, Kivikoski, Syndänheimo, 2003). There are three systems that can be used with public frequencies. There are two more popular systems (Attaran & Attaran, 2004; Durfee, Goodrum & McLaren, 2006; Ei-Misalami & Jaselskis, 2003; Keskilammi, Syndänheimo Kivikoski, 2003; Krivda, 2004; Piramuthu, 2006; Rao, 2005), passive and active

Passive systems. In a passive RFID system, a tag is excited only when it passes through the energy field of the interrogator. It is a very simplistic way of thinking of a complex technology, but it starts the mindset of this technology. Formally, Rao (2005) defined the operation of a passive RFID system as the following, "A passive back-scattered RFID system operates in the following way. A base station (reader) transmits a modulated signal with periods of un-modulated carrier, which is received by the tag antenna. The RF voltage developed on antenna terminals during un-modulated period is converted to dc. This voltage powers up the chip, which sends back information by varying its front end complex RF input impedance. The impendence typically toggles between two different states, between conjugate match and other impedance, effectively modulating the back-scatter signal." A simpler way of thinking of this idea is that the reader transmits a modulated radio frequency signal to the tag, which consists of an antenna and an integrated circuit chip. The chip then receives power from the antenna and responds by varying its internal input impedance, which is how the backscatter signal is modulated. Amplitude shift keying (ASK) is used in RFID. This means the chip's impedance lands between two states: one is matched to the antenna and the other state is drastically mismatched (Lam, Nikitin & Rao, 2006). Once the chip is "excited" by the magnetic field it modulates the waves that they tag send back to the reader and the reader converts the new waves into digital data.

Backscatter technology is used in passive RFID systems. The backscatter uses load modulation for the communication. As described earlier the signal comes from the RFID reader. The return signal from the tag to the reader is altered. This means the processing circuit on the tag changes the radio frequency impendence of the tag antenna and controls the amount in the scattered field that is sent back to the reader (Keskilammi, Syndänheimo & Kivikoski, 2003). In RFID technology, the tag is identified when the backscattered filed is received and decoded by the reader's unit.

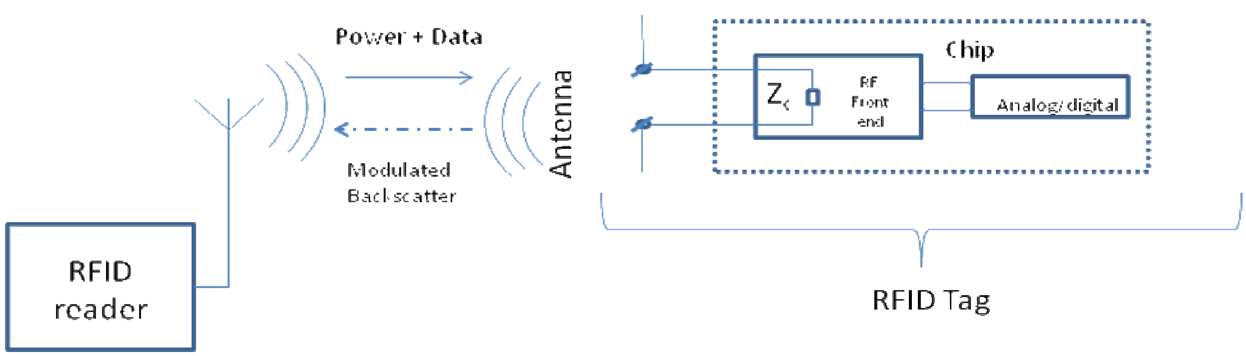

Figure 8. Passive RFID system (Lam, Nikitin & Rao, 2006)

A determining factor the adoption of this technology is the bottom-line cost. The passive system is cheaper by than an active system. The cost of the passive system comes at the expense of the transmitting power. The passive system also has small data storage capabilities that are between 128 to 256 bytes (Goodrum et al., 2006). The tags have an infinite life time because they have no external batter source. Passive tags can be found in high volume operations because of their size, weight, and restrictions (Keskilammi, Syndänheimo & Kivikoski, 2003).

Active system. In an active RFID system the transponder or tag, has its own power source. Normally, the tag is battery operated. With an imbedded battery, the ready ranges of active tags significantly differ from the read ranges of the passive system. An active system typically has more memory capabilities. In comparison to the passive tag, the active tag can hold 32 to 128 kilobytes of memory (Goodrum et al., 2006). Generally, the purposes of the more expensive tags are the more complex operations that can be carried out. They are usually used when logging temperature, humidity or other environmental parameters (Keskilammi, Syndänheimo & Kivikoski, 2003).

As with any emerging technology there are drawbacks and disadvantages. In addition to the costs, there are a variety of other limitations that come into consideration when looking to implement a full scale RFID system. There is no standardization. This means there are restrictions on the reader/tag relationship. One manufacturer's reader cannot read another manufacturer's tag, which could impact the partial implementation of the technology (El-Misalami & Jaselskis, 2003).

The power of this technology is immense. With the power of this technology comes the fear of how intrusive it can become in the future. Safety, security, and privacy issues are now debated over this technology (Smith, 2005). Public adoption of the technology that his not fully understood, is likely to fail. The push for RFID to be used in a retail setting currently endangers the public private information such as purchasing practices as well as credit card information because there is not industry standard by which the information needs to be discarded.

Failure rate is another issue facing RFID; the unexplained failures in the field have not been fully explored. What offsets the burdens of the technology is the ability to have a huge impact throughout all industries.

Methodology

The instructional design designated for this project is the ASSURE model. From this model, the methodology was selected.

Analyze the Learner

The typical Industrial Distribution student is between the ages of 20-25. The Industrial Distribution major trends slightly higher than the University average at 12.7% female enrollment with a majority of the student population being in state. It is vital that the learning population was fully understood prior to the learner's exposure to the technical material—this included educational background, prior exposure to the material/technology being used, and demographic. The analysis of the learner occurred prior to introduction of material in order for the study to be valuable.

Prior knowledge of the learning characteristics of the student population served as an analysis. It was observed that the student learned best through active experimentation along with concrete experiences. The learners' needs were best met when the questions of "what if" or "how" were explored. This reflects Kolb's (1986) Concrete Experience and Active Experimentation learning cycles.

State Objectives

The stated objectives for the RFID learning module were clearly defined and reflect curriculum objectives. After the students' exposure to the learning module, they are able to:

- Paraphrase the fundamental workings of an RFID system
- Demonstrate mastery of simple RFID calculations such as wavelength, frequency, and near field communication
- Explain how an active and passive RFID system work

- Identify RFID components

Obtainable objectives were important because they determined the direction of the course as well as what the learner was expected to learn (Kolb, 1986).

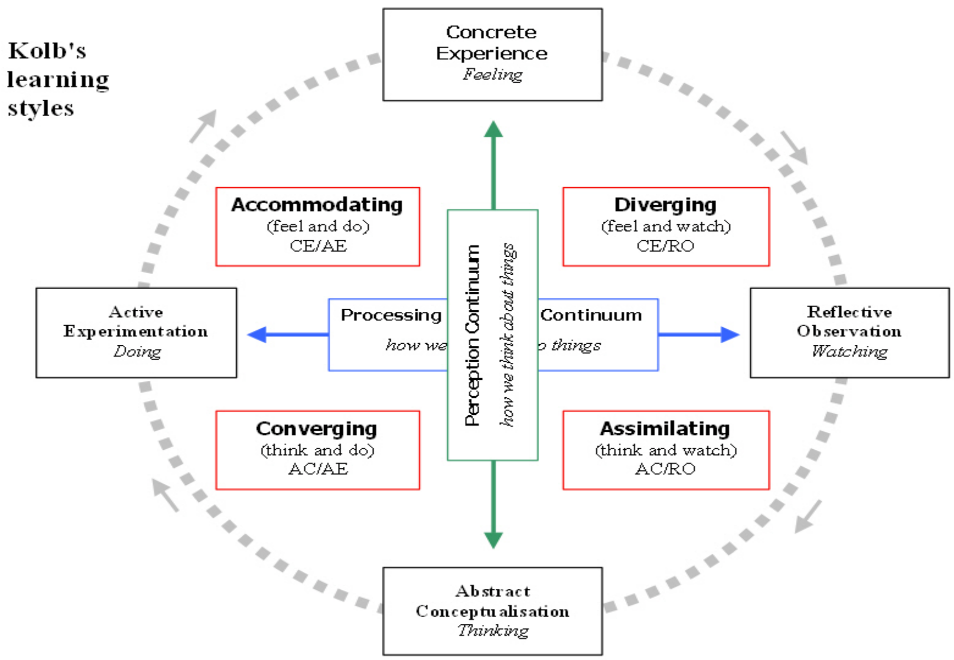

Figure 9: Kolb's learning style diagram. Taken from: www.businessballs.com

Objectives can be identified by terminal behavior and established condition. Terminal behavior defined what the expected outcomes of the learning module were. Conditions were established based on the technical expertise obtained by the learning module. By using Bloom's Taxonomy of cognitive objectives (1956), it was determined that objectives would measure their knowledge, comprehension, and analysis of the subject matter. Knowledge was established by having the student's list parts of the RFID system as well as identifies the differences between passive and active tags.

Comprehension was determined by having the students describe and predict the behavior of various tags when interacting with the RFID systems' antennas. Furthermore, both the lecture and lab covered this information. Finally, the students demonstrated their ability to analyze the material by being able to compare, differentiate, and categorize RFID's strengths and weaknesses as compared to other technology.

Select the Media & Material

When the media was selected, the following was considered:

- The media must be readily available for future use
- The media must be able to accessed remotely
- The media must be able to be altered in the future

Adobe Connect was used because of its ability to be accessed remotely, ability to present PowerPoint presentations, ability to be recalled for future use, and the ability to have voice recordings.

Knoy B044 was the room selected to perform the lab experiment. This room was chosen because it has the Alien Technology RFID system. The room is secured through a biometric hand reader. Students performed a series of events that demonstrated their comprehension and analysis of the subject matter (See Appendices A—H). The topics covered in the lab were selected due to applicability in industry. The algorithm to calculate the backscatter was not included, rather the ability for the student to read, understand, and calculate the fundamental aspects of the technology were included.

Utilize Material:

Microsoft PowerPoint was used to display the lecture material. Adobe was used to convey the material through a seminar meeting room with the ability to hear the voice recorded lecture. The lecture would also be supplemented with a note taking activity (See Appendix I) that would allow the students to demonstrate knowledge as well as served as a reference point to the material covered. Due to the mobility of access, Adobe, the modules will be able to be reviewed on multiple occasions. The lecture can be found at: https://gomeet.itap.purdue.edu/p97215007/ . In order to see the lecture, the link must be copied and pasted.

Require Learner Participation:

All students were required to perform laboratory activities that supplement the classroom instruction. The use of this module was intended for multiple Industrial Technology courses. This module required that participants work independently as well collaboratively to successfully prove that learning has occurred.

Evaluation/Review:

This final step was completed using a MS Technology graduate student who performed the tasks in the instructor's guide. The feedback that was incorporated into the laboratory experiment, as well as modifying the instructor's guide for conducting the lab. The modular based reinforcement exercise consisted of short answer, multiple choice, and true/false questions. The laboratory's supplemental documents are sorted in a way that students have to work independently in order to demonstrate learning. The learning modules intended to help supplement classroom instruction from basic concepts to the theory of backscatter.

Discussion/Conclusions

Globalization's constant need for more with less has put a strain on the evolution of manufacturing has brought many large United States manufacturers to use methods that will increase the traceability of the product while continuously cutting cost. This continual push for cutting edge technology has made RFID a reality in their supply chain. Although its historical roots date back to World War II, a new purpose for the technology has given the technology a second breath.

Overall, this project's goals were met. With the completion of this project the education materials to enhance the working knowledge of Radio Frequency Identification (RFID) within the Industrial Technology department was created. Future educational materials could be created to supplement this project such as a flow chart to aid students in showing major factors in making decisions when RFID is appropriate. Industry collaboration with businesses that utilize RFID would also impact the student's learning of RFID.

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Appendix

Appendix A: RFID Lab Instructor Guidelines

Overview:

This lab will give students the opportunity observe RFID technology in the Supply Chain Lab (Knoy B044), identify RFID components, as well as demonstrate mastery of simple RFID calculations such as wavelength, frequency, and near field communication.

The lab has four phases: introduction, planning, execution, and review.

Materials and Equipment:

The following is the equipment for one group of four students:

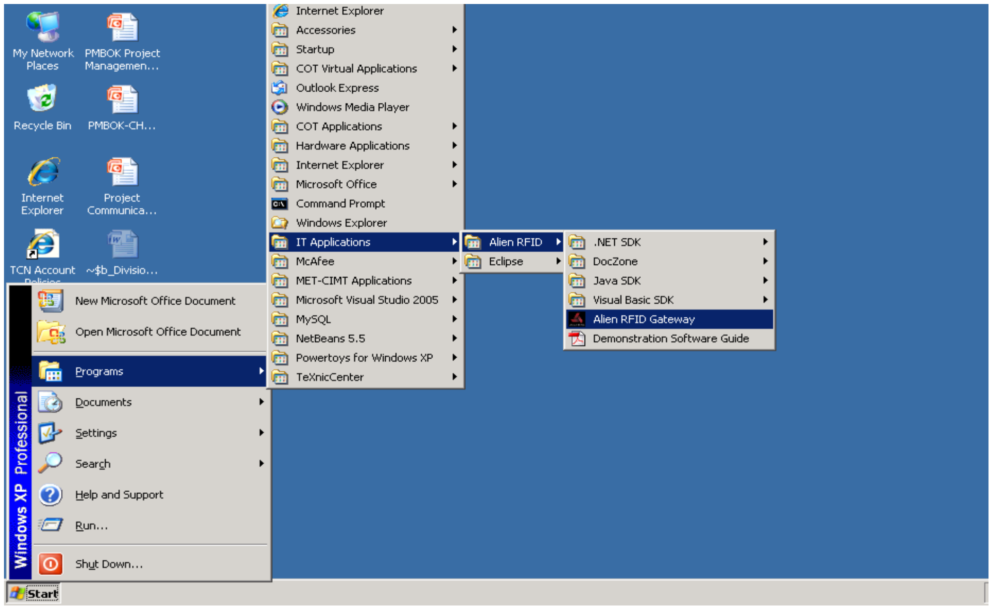
- 4 RFID tags
- 1 Tape Measurer
- 1 Roll of Masking Tape

Pre-lab Preparation:

Handouts:

- RFID lecture note sheet
- Measurement tables
- Follow-up discussion sheets

Equipment: Alien Technology operation



Pre-activity Discussion:

Before the lab begins review the procedures with the students.

Activity:

Groups of four (4) members should be divided in the following manner:

Observer

Tag Holder

Measurer

Recorder

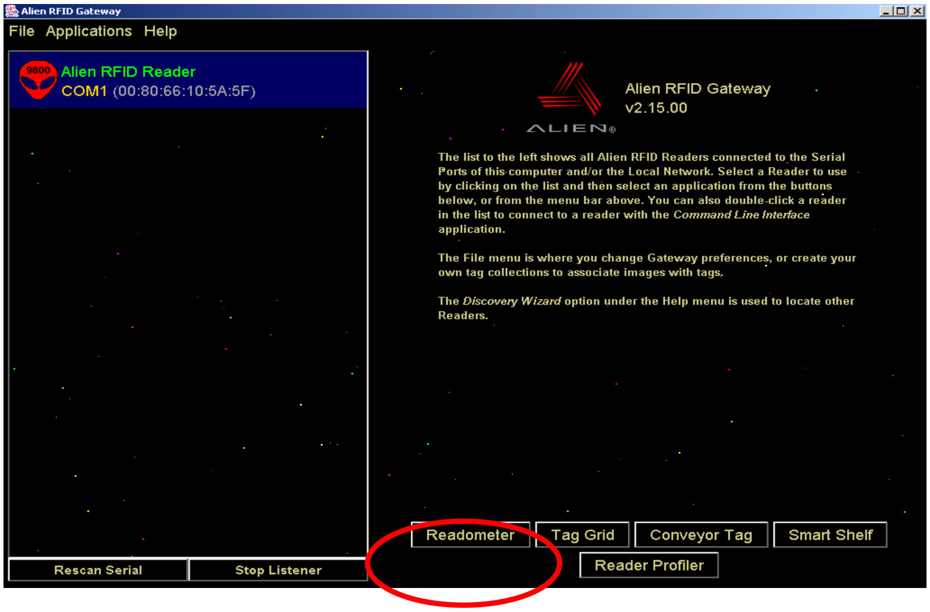
Observer: ensures that the Alien Technology is properly working on the screen. Also indicates when the tag is recognized by the reader

Tag Holder: records initial tag property and data number prior to the start. Selects certain spots within the room

Measurer: accurately reflects the distance from the selected antenna(s) to the tag holder in the form of a straight line indicates where the tag holder stops/stands.

Recorder: indicates where the tag holder stops/stands. Records the various elements of the database system

1. Ensure Alien Technology is on the "readometer"



2. Once the readometer is displayed. The following should be on the screen.

3. Make sure the following remain:

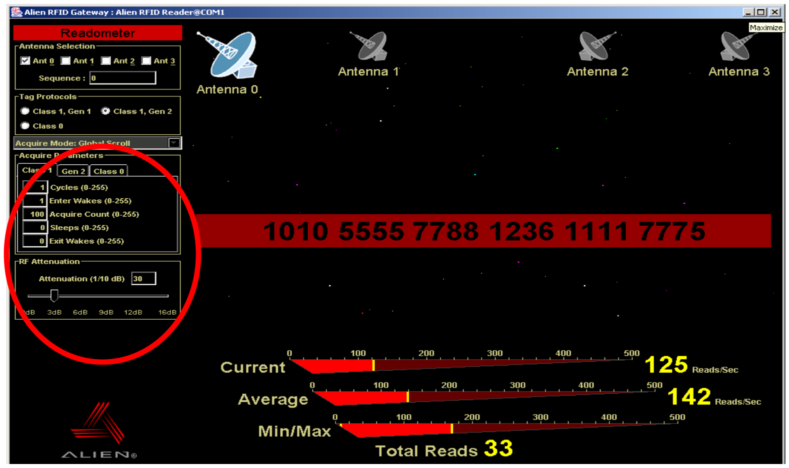
Cycles: 1

Enter Wakes: 1

Acquire Count: 100

Sleeps: 0

Exit Wakes: 0



4. With the tag holders’ back to the atenna start 15 feet from an antenna.

   i. If the tag is not read at 15 feet, move closer to the atenna(s) by 6 inches at at time

5. The observer should notify the group when the tag is recognized

6. When the tag is read the measurer should mark where the group member was standing.

7. The recoder need to note the following:

Antennas Selected: A0 A1 A2 A3

Annenuation:

Distance:

Tag Number: _ _ _ _/_ _ _ _/_ _ _ _/_ _ _ _/_ _ _ _/_ _ _ _

8. Once the distance is recorded, allow another group to obtain their measurements

9. While you wait, complete the measurement table.

10. Repeat steps 1 through 8 until 4 measurements are taken. Make sure every member of the group has an opportunity to be the observer, tag holder, measurer, and recorder.

Appendix B: RFID Student Instructions

Overview:

This lab will give students the opportunity observe RFID technology in the Supply Chain Lab (Knoy B044), identify RFID components, as well as demonstrate mastery of simple RFID calculations such as wavelength, frequency, and near field communication.

The lab has four phases: introduction, planning, execution, and review.

Materials and Equipment:

The following is the equipment for one group of four students:

5 RFID tags

2 Tape Measurer

2 Roll of Masking Tape

Pre-activity Discussion:

Before the lab begins review the procedures with the students.

Activity:

Groups of four (4) members should be divided in the following manner:

Observer

Tag Holder

Measurer

Recorder

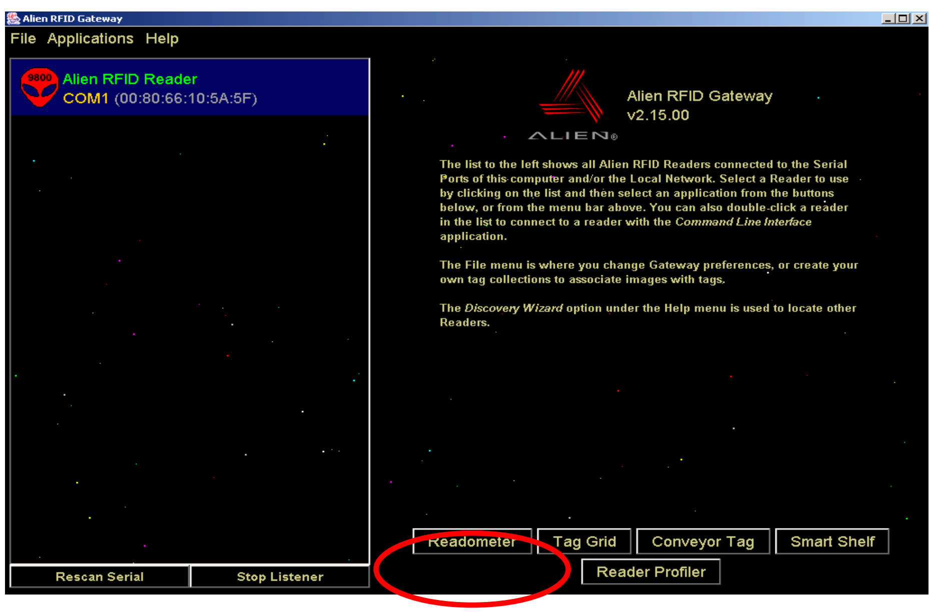
Observer: ensures that the Alien Technology is properly working on the screen. Also indicates when the tag is recognized by the reader

Tag Holder: records initial tag property and data number prior to the start. Selects certain spots within the room

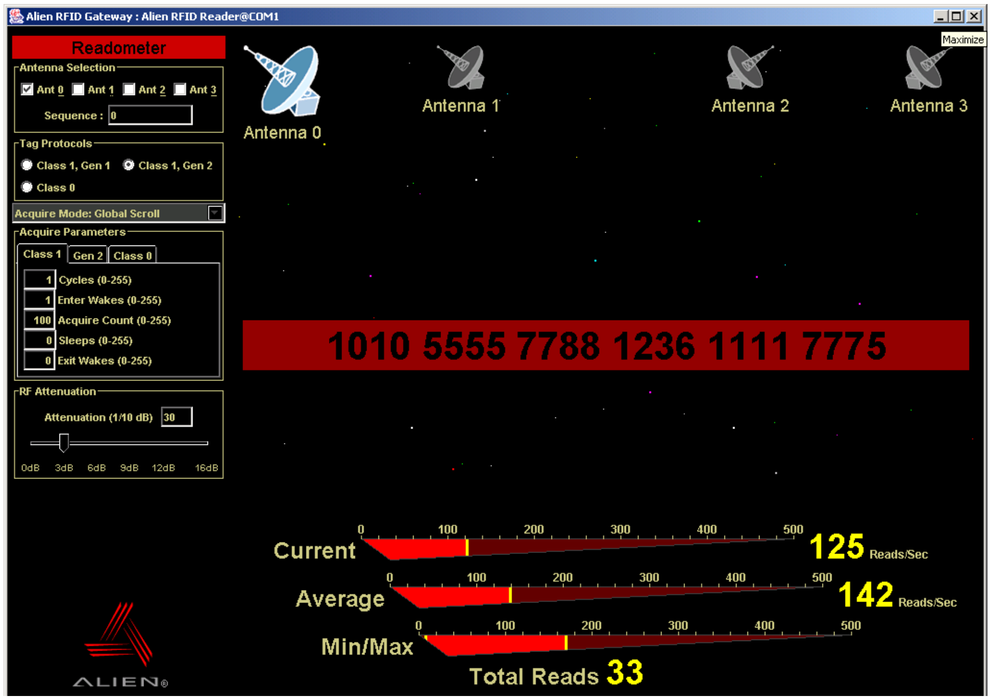
Measurer: accurately reflects the distance from the selected antenna(s) to the tag holder in the form of a straight line indicates where the tag holder stops/stands.

Recorder: indicates where the tag holder stops/stands. Records the various elements of the database system

1. Ensure Alien Technology is on the "readometer"



2. Once the readometer is displayed. The following should be on the screen.



3. Make sure the following remain:

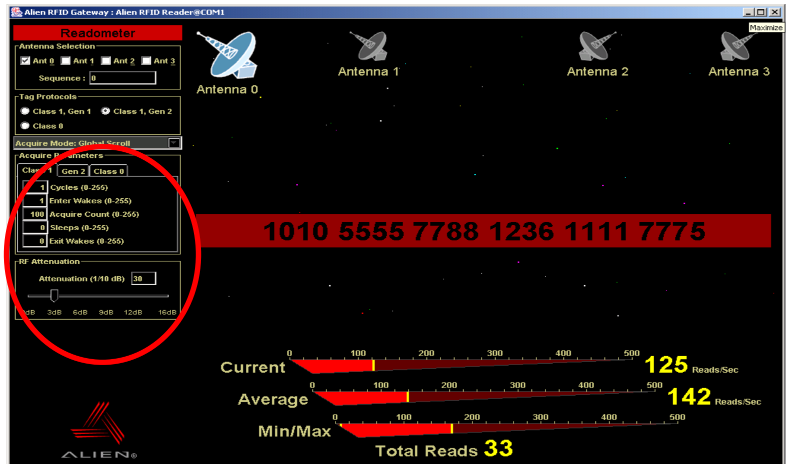
Cycles: 1

Enter Wakes: 1

Acquire Count: 100

Sleeps: 0

Exit Wakes: 0



4. With the tag holders' back to the atenna start 15 feet from an antenna.

   i. If the tag is not read at 15 feet, move closer to the atenna(s) by 6 inches at at time

5. The observer should notify the group when the tag is recognized

6. When the tag is read the measurer should mark where the group member was standing.

7. The recoder need to note the following:

   Antennas Selected: A0 A1 A2 A3

   Annenuation:

   Distance:

   Tag Number: _ _ _ _/_ _ _ _/_ _ _ _/_ _ _ _/_ _ _ _/_ _ _ _

8. Once the distance is recorded, allow another group to obtain their measurements

9. While you wait, complete the measurement table.

10. Repeat steps 1 through 8 until 4 measurements are taken. Make sure every member of the group has an opportunity to be the observer, tag holder, measurer, and recorder.

Appendix C: Measurement Table 1

Read #________:

Antennas Selected: A0 A1 A2 A3

Annenuation:

Distance:

Tag Number: _ _ _ _/_ _ _ _/_ _ _ _/_ _ _ _/_ _ _ _/_ _ _ _

With the distance recorded we can calculate the frequency as well as the near field communication distance.

- λ = c / v
  - C is the speed of light (3 x 10^8 m/s)
  - V is the given wavelength
  - λ unit of measurement is meters (m)
- Inductive coupling only works in a close proximity communication.
  - [1/ (2π) multiplied by the wavelength]
- λ = c / v
  - C= (3 x 10^8 m/s)
  - V=12.34 MHz
  - λ =

  [1/ (2π) multiplied by the wavelength]
- λ = c / v
  - C= (3 x 10^8 m/s)
  - V=13.56 MHz
  - λ =

  [1/ (2π) multiplied by the wavelength]
- λ = c / v
  - C= (3 x 10^8 m/s)
  - V=32.25 MHz
  - λ =

  [1/ (2π) multiplied by the wavelength]

Appendix D: Measurement Table 2

Read #________:

Antennas Selected: A0 A1 A2 A3

Annenuation:

Distance:

Tag Number: _ _ _ _/_ _ _ _/_ _ _ _/_ _ _ _/_ _ _ _/_ _ _ _

With the distance recorded we can calculate the frequency as well as the near field communication distance.

- λ = c / v
    - C is the speed of light (3 x 10^8 m/s)
    - V is the given wavelength
    - λ unit of measurement is meters (m)
- Inductive coupling only works in a close proximity communication.
    - [1/ (2π) multiplied by the wavelength]

- λ = c / v
    - C= (3 x 10^8 m/s)
    - V=13.56 MHz
    - λ =

[1/ (2π) multiplied by the wavelength]

- λ = c / v
    - C= (3 x 10^8 m/s)
    - V=15.7 MHz
    - λ =

[1/ (2π) multiplied by the wavelength]

- λ = c / v
    - C= (3 x 10^8 m/s)
    - V= 868 MHz
    - λ =

[1/ (2π) multiplied by the wavelength]

Appendix E: Measurement Table 3

Read #________:

Antennas Selected: A0 A1 A2 A3

Annenuation:

Distance:

Tag Number: _ _ _ _ /_ _ _ _ /_ _ _ _ /_ _ _ _ /_ _ _ _ /_ _ _ _

With the distance recorded we can calculate the frequency as well as the near field communication distance.

- $\lambda = c / v$
  - C is the speed of light (3×10^8 m/s)
  - V is the given wavelength
  - λ unit of measurement is meters (m)
- Inductive coupling only works in a close proximity communication.
  - [1/ (2π) multiplied by the wavelength]
- s$\lambda = c / v$
  - C= (3×10^8 m/s)
  - V=868 MHz
  - $\lambda =$

[1/ (2π) multiplied by the wavelength]

- $\lambda = c / v$
  - C= (3×10^8 m/s)
  - V=10.7 MHz
  - $\lambda =$

[1/ (2π) multiplied by the wavelength]

- $\lambda = c / v$
  - C= (3×10^8 m/s)
  - V= 12.58 MHz
  - $\lambda =$

[1/ (2π) multiplied by the wavelength]

Appendix F: Measurement Table 4

Read #________:

Antennas Selected: A0 A1 A2 A3

Annenuation:

Distance:

Tag Number: _ _ _ _/_ _ _ _/_ _ _ _/_ _ _ _/_ _ _ _/_ _ _ _

With the distance recorded we can calculate the frequency as well as the near field communication distance.

- $\lambda = c / v$
  - C is the speed of light (3×10^8 m/s)
  - V is the given wavelength
  - λ unit of measurement is meters (m)
- Inductive coupling only works in a close proximity communication.
  - [1/ (2π) multiplied by the wavelength]
- s$\lambda = c / v$
  - C= (3×10^8 m/s)
  - V=9.78 MHz
  - λ =

  [1/ (2π) multiplied by the wavelength]

- $\lambda = c / v$
  - C= (3×10^8 m/s)
  - V=10.7 MHz
  - λ =

  [1/ (2π) multiplied by the wavelength]

- $\lambda = c / v$
  - C= (3×10^8 m/s)
  - V= 13.56 MHz
  - λ =

  [1/ (2π) multiplied by the wavelength]

Appendix G: Adobe Connect Lecture Notes

What does R F I D represent?

R

F

ID

What are the three components of an RFID system?

1.

2.

3.

What is another name for *transponders?*

What are the two major categories for tags?

What are distinct differences between the two types of tags?

Class	Memory	Power Source
		Passive
1		Any
	Read-Write	
3		Active

4		

What is another name for the transceiver?

What is the purpose of the transceiver?

Describe the forward channel of communication.

Describe the backward channel of communication.

What are the thresholds for low frequencies? __________ to ___________

What is the typical frequency used for RFID system? Why is this frequency used?

Briefly describe how an active and passive system works.

Active

Passive

Passive tags receive power through _________ ___________.

How do you calculate the distance of the wavelength?

How do you calculate near field communication?

What does the near field communication tell you?

What are 2 characteristic you should consider when deciding if RFID is an appropriate solution?

1.

2.

List the advantages and disadvantages of RFID

Appendix H: Adobe Connect Lecture Notes Answers

What does R F I D represent?

R adio

F requency

ID entification

What are the three components of an RFID system?

1. Transponder

2. Transceiver

3. Back End Database System

What is another name for *transponders?*

"Tag"

What are the two major categories for tags?

1. Passive
2. Active

What are distinct differences between the two types of tags?

Class	Memory	Power Source
0	None	Passive
1	Read-only	Passive or Active
2	Read-Write	Passive or Active
3	Read-Write	Active
4	Read-Write	Active Only

What is another name for the transceiver?

"Reader"

What is the purpose of the transceiver?

Interrogate the tag

Describe the forward channel of communication.

Forward Channel communication allows the "reader" to excite the "tag" through radio frequencies

Describe the backward channel of communication.

Backwards Channel communication occurs when the tag excites the "reader"

What are the thresholds for low frequencies? ___9kHz______ to ____13.56MHz______

What is the typical frequency used for RFID system? Why is this frequency used?

13.56MHz. It is used frequently because it is free and requires no license to operate within its bandwidth.

Briefly describe how an active and passive system works.

Active: The "tag" must be attached to the item of interest. The item should not be conductive. The "tag" will initiate any communication with the "reader". Through radio frequency modulation, the data will be transmitted from the tag to the reader. The backend database system interprets the data stored on the tag and displays it in a manner that makes sense to the end use customer.

Passive: The "reader" through radio frequencies will initiate communication with the reader. The "reader" will excite the "tag", which will then alter the radio frequencies. The backend database system will interpret the data stored on the tag and displays it in a manner that makes sense to the end use customer.

Passive tags receive power through *inductive coupling*.

How do you calculate the distance of the wavelength?

- $\lambda = c / v$
  - ➢ C is the speed of light (3×10^8 m/s)
  - ➢ V is the given wavelength
  - ➢ λ unit of measurement is meters (m)

How do you calculate near field communication?

[1/ (2π) multiplied by the wavelength]

What does the near field communication tell you?

How close the transponder needs to be to the antenna in order to ensure proper reading is successfully completed.

What are 2 characteristic you should consider when deciding if RFID is an appropriate solution?

1. Type of data the needs to be retrieved from the tag
2. How often the data needs to be retrieved.
3. Quantity of product
4. Material that the tag will be attached to
5. Government regulations
6. Customer privacy issues

List the advantages and disadvantages of RFID

Advantages	Disadvantages
No line of sight required	High start up costs
Can make multiple reads per second	Privacy threats in the non-manufacturing arena
Can retrieve, add, edit, and update product information	Collision: When multiple tags respond simultaneously to a reader interrogation
Can contain more product information than any other form of auto-identification system	