A Learner-Centered Approach to Industrial Technology Education: A Case Study of a Multimedia Team Project

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Abstract
The purpose of this paper is to present a case study of a university multimedia team project, taught as a learner-centered alternative and enhancement to a lecture-only traditional approach to industrial technology education. Creation of Flash movies integrated with interdisciplinary content can be used not only for student learning in an academic environment, but also for transfer to the training of the industrial technologist.

In a higher education milieu, the prevailing approach to teaching and learning is external. The professor determines what to do to and for the student in order for learning to take place. The internal learner-centered approach is to shift the responsibility of learning to the student, so that the student becomes the center of the educational process and becomes an active decision-maker by making choices on how his or her learning will take place. The professor's role is transformed to that of a facilitator and supporter of the learning process. This learner-centered education prepares students for lifelong learning and transferable skill sets.

Macromedia Flash, a vector-based animation software, can be used to create multimedia learning objects for the academy, as well as for training in industry. In this case study, graphics students were challenged on how to create organic chemistry molecular structures using Flash animation. The challenge to the professor was to examine alternative shifts in attitude as to how learning should take place, and how the presentations should be used in visual and verbal formats for optimal learning.

I. What is Learner-Centered Education?

There is a quiet revolution occurring in higher education — a change of philosophy on how one teaches, how one learns, how a classroom is structured, how faculty and college students relate to each other, as well as in the nature of the curriculum. Learner-centered education and the philosophy of learning, encompass issues from society, the quest for life-long learning, the culture of the evolving university classroom, and technology. Learner-centered education focuses on the interest, skills, and needs of the student, with the computer as the vehicle of learning.

In the academy, the professor typically determines what to do to and for the student in order for learning to take place. The internal learner-centered alternative is to shift the responsibility of learning to the student, so that the student becomes the center of the educational process and becomes an active decision-maker by making choices on how his or her learning will take place. The professor's role is transformed to that of a facilitator and supporter of the learning process. Learner-centered education prepares students for lifelong learning and skill sets that are transferable to industry.

II. Bridging the Gap Between Industry and Academia

The majority of the world is besieged with digital information where things are changing at an alarming rate. The Internet, print, television, and other media are evidence of the importance of communicating through visual communication, the written word, and auditory cues. Learning how to communicate through technology helps to confirm technology as a catalyst for change in our society. The majority of careers in the United States are threaded with technology. The lack of technical and visual literacy in the workforce is a prevailing problem in the United States, especially since many jobs require this knowledge.

The economic health of the United States is dependent on workers who are competent in technology. Graphic communications is ranked among the largest industries in the United States. The $5.8 billion graphic design industry alone has more than 16,000 businesses and spends more than $400 million each year on capital goods.[1]

Informed decision-making in a democratic society is dependent on managers who are technologically literate and who can communicate using technology. Knowing how to apply technology and interrelate it to one's field of expertise impacts the life of the American consumer. Once industrial professionals are willing to expand their minds and the definition of "graphic communications" to embrace not only printed outputs, but multimedia and Website design and development, the discipline and industry will grow substantially. Part of being an industrial technologist is designing information, whether the output be Internet, print, or CD/DVD.

But technical and visual literacy is not all that is necessary for sustainable economic growth. American and international businesses in the 21st Century need strategic employees who know how to think, and who understand people, as well as technology in order to produce economic results.

In Arizona, the university system Board of Regents has produced a Statement of Principles for Learner-Centered Change and has approved of the Arizona Faculties Council's Definition of Learner-Centered Education.[2] They have mandated that it is the responsibility of the academy to create an environment which is conducive to learner-centered education.

The challenge for today's industrial technology faculty is to engage students with different learning styles through learner-centered education. The challenge for today's university student is to take responsibility for his or her own learning through active engagement, critical and creative thinking, and problem solving, and apply it to the industry job.

III. Methodology

The methodology of this case study was based on multi-method survey and focus group activities that were both quantitative and qualitative in nature. The success of the project was determined by the analysis of the data from the pre/post tests, focus groups, and evaluations through process measures used to assess student involvement, skills, knowledge, and educational progress.

Twelve graphic information technology (GIT) students at Arizona State University, who were enrolled in GIT 314 Multimedia Design Planning and Storyboarding, participated in this study.

There were nine males and three females. The average age was 23.

Students applied their technical and creative skill sets to solve real and simulated industrial problems. Students were assessed on their critical and creative thinking skills, the application of their technical and creative knowledge, their teamwork skills, and how they incorporated problem solving. The competency-based assessment through pre/post tests, scientific lab reports, individual contributions, teamwork, evaluations, and electronic presentations met the rigor and standards of the academe. Instruments were developed around authentic assessment strategies, such as the use of rubrics to describe the attainment of parameters of competency, and reviews of student activities through self, peer, team, and faculty evaluations. Self-assessments and peer performance assessments were given to the professor in confidentiality.

III. Goals and Objectives

The professor's goal was to facilitate learning and propel lifelong learning behavior[3] that could be applied to the real world. Since a goal describes in broad terminology the long-term intent of the activity, [4,5] the ultimate goal of this team project was to provide an effective and accessible learning-centered activity for linking the interdisciplinary nature of multimedia technology to other unrelated university curricula, such as organic chemistry. It provided evidence of an interdisciplinary project that featured a strong foundation in graphic technology content knowledge that was related to effective pedagogical strategies. The goals of the activity were to significantly increase the number of future workforce employees, who are technologically and visually literate, and by improving the quality of the university student. The focus of the project was on continued professional growth in technological, visual literacy, people, and production skills.

The objectives of the team project, on the other hand, were more specific in nature, short-term and measurable.[5] They addressed higher-order thinking and required problem solving, application, evaluation, synthesis, and analysis, which are reflective of the domains of Bloom's Taxonomy.[6] Objectives were measured by observing, listening, and analyzing work. In addition, they were measured by pre/post tests, and self, peer, and teamwork evaluations.

In a "real-world learning situation," learner-centered psychological principles need to be applied in order to ensure the success of the learning process.[7] The principles were applied through cognitive, affective and skill set objectives. The knowledge and intellectual skills necessary for developing thinking skills fit in the cognitive category. This is informational knowledge that students did not know before the learner-centered activity took place. The development of new values, attitudinal changes, new interests, and "social dimensions of outcomes" were listed in the affective category.[8] Bloom (1956)[6] presents the third level of learning as the "psychomotor." The author instead, categorized the domain as "skill objectives" with activities such as presenting, writing, etc., which were the outcomes. Critical and creative thinking skills were developed in this course through: (1) learned activity, (2) inquiry, (3) balancing thinking with theories, (4) focusing on processes, (5) establishing a non-judgmental setting, and (6) problem solving.[9]

IV. The Multimedia Design Process

In this study the students were introduced to the multimedia design process. The design process was important to learner-centered education because it integrated related courses and overall curriculum, and bridged academic areas for interdisciplinary efforts. The project's purpose was also aimed at simulating those situations currently in the workforce that need visual, technical, and teamwork skills.

The professor guided the process by giving the students the expectations of the final outcome. Animations of molecular structures, which were to be used as learning objects for an online organic chemistry course, were created. How this goal was to be reached was the ultimate responsibility of the students in the class. The stipulation was that it had to look like the same information designer created each molecular structure. The professor had to take the complex academic content and intentionally construct meaning from the experience. In order for the experience to be learner-centered, the students determined what actions must be taken in order to reach the significant goals. The professor had to assist by giving no answers — only questions. This prompted the students to be self-regulated, assume responsibility for their actions, and to depend on each other in order to get their part done.

Forming a Team

The team project included opportunities for undergraduate and graduate students, enrolled in Arizona State University's graphic information technology course, to create a multimedia team. Students were engaged in learner-centered activities through the creation of this multimedia team. A variety of instructionally tools and methods were used, which facilitated personal and interpersonal discovery and individually guided inquiry. Student learning also included problem-based inquiry, self-paced tutorials, collaborative teamwork, and experiential activities. In addition to face-to-face time, they participated in virtual chats and online discussion forums.

Previous to the team project assignment, the students in the Multimedia Design Planning and Storyboarding course had presented individual projects. This enabled the professor to assess the strengths of each student.

At the beginning of the team project, the students and the professor had an engaging and open discussion on the roles and responsibilities of each person on a multimedia team. There was a great amount of laughter and excitement when the professor determined the strengths of each member, and appointed a job title to each student. Twelve job titles were developed in order for tasks to be completed: (1) project manager, (2) graphics editor, (3) multimedia librarian, (4) animation consultant, (5) IT guru, (6) text editor, (7) research and development tester, (8) Flash technical support, (9) corporate presenter, (10) content coordinator, (11) template generator, and (12) art director.

Because many in the class were naïve to the team dynamics of a real world creative and production team, the professor used examples from industry to clarify any misperceptions of responsibilities. Each student was presented as a resource to every other student, and part of their success of this project was to be determined by how they shared their talents and strengths with each other.

Design Phase I: Discovery and Research

After a client provides the content, the data is designed and organized. More often than not, the content is unfamiliar to the multimedia designer. In keeping with the real world scenario, the client for this project was an organic chemistry professor from ASU. He was not familiar with Flash animation software capabilities. He was teaching an online organic chemistry course for beginners. The goal was to create a multimedia movie prototype for his Website to aid in the learning of organic chemistry. Since the students in the multimedia course were also beginning Flash technology users, it was a challenge to use this activity as a learner-centered project.

The multimedia team was divided into sub-teams to discuss questions to ask the client. Since the industrial technology professor had initially approached the client on improving the organic chemistry Website through the use of multimedia, a more proactive approach had to be initiated. Because of the inexperience of the students, they allowed the client to control the interview and ended up getting a lecture on organic chemistry. When a student asked, “Would you like Flash animations on your Website?” the client replied, “You’re the graphics expert. You tell me.” At the end of the interview the students were left confused and without content. This was a valuable part of the learning experience. A discussion followed facilitated by the industrial technology professor. She explained that in the case where the team is initiating adding the multimedia to the Website, it is their responsibility to prove to the client why it is significant. The students needed to come to the interview more prepared with suggestions to give the client, instead of asking the client what he wanted. This reflective process was invaluable.

Since the organic chemistry professor was not available for another interview, a chart out of the chemistry textbook was used as the content to create the multimedia learning objects. This was done with the approval of the chemistry professor. Each student was assigned a molecular structure to animate by the content coordinator.

Figure 1. Organic chemistry chart

The First 20 Alkanes with Unbranched Chains

NAME	MOLECULAR FORMULA	NAME	MOLECULAR FORMULA
methane	CH_4	undecane	$C_{11}H_{24}$
ethane	C_2H_6	dodecane	$C_{12}H_{26}$
propane	C_3H_8	tridecane	$C_{13}H_{28}$
butane	C_4H_{10}	tetradecane	$C_{14}H_{30}$
pentane	C_5H_{12}	pentadecane	$C_{15}H_{32}$
hexane	C_6H_{14}	hexadecane	$C_{16}H_{34}$
heptane	C_7H_{16}	heptadecane	$C_{17}H_{36}$
octane	C_8H_{18}	octadecane	$C_{18}H_{38}$
nonane	C_9H_{20}	nonadecane	$C_{19}H_{40}$
decane	$C_{10}H_{22}$	eicosane	$C_{20}H_{42}$

The students defined the problem to be solved through brainstorming activity. The discovery and research phase initiated ideas on how to solve the problem and what conceptual design would be used. Through competitive analysis, students researched how others had solved this problem and discussed the best solution for them, given the time allotted and their limited technical skills.

Design Phase II: The Architecture Phase

Before the students could determine how the project was going to be implemented, they had to determine a strategic plan. The students were familiar with the design process of creating storyboards and scriptwriting for their individual projects. They were not familiar with doing a team project in which everyone was assigned a different part of the project. No one knew what to do first, so a strategic plan was developed with a list of all the tasks that needed to be accomplished, areas of responsibility, and a timeline. It was determined that it was the project manager’s responsibility to organize these tasks and see that they were carried out.

Since all molecular structures had to be consistent visually, technically, and content-wise, the industrial technology professor introduced the concept of standardization for content and design consistency. After a lengthy discussion in which everyone participated, the appointed standardization team had the ultimate decision-making power. Everyone had to live with the decisions, even if it was contrary to their opinion.

The architectural phase involved the scriptwriting of the concept, which was the content coordinator's area of responsibility. The students determined that the sequence of motion in the script needed to be the same for each molecular animation and a standard was added to the design guidelines of the project. The content coordinator met with the client to have the content approved. The molecular structures were simplified after the meeting with the client, and the content coordinator assigned molecular structures to the team.

Figure 2. Organic chemistry script sample

Setting:
The video will be viewed either inside of a Web browser or as a stand-alone program on a computer screen. It will have a white background without any border, a 640*480 screen size, and 24 fps.

The Characters:
Black text in the Lithograph font
Blue gradient circular carbon atoms
Red gradient circular hydrogen atoms
Two different sizes of gray bonds that will connect the two
The carbon atoms will be larger in size than the hydrogen atoms.

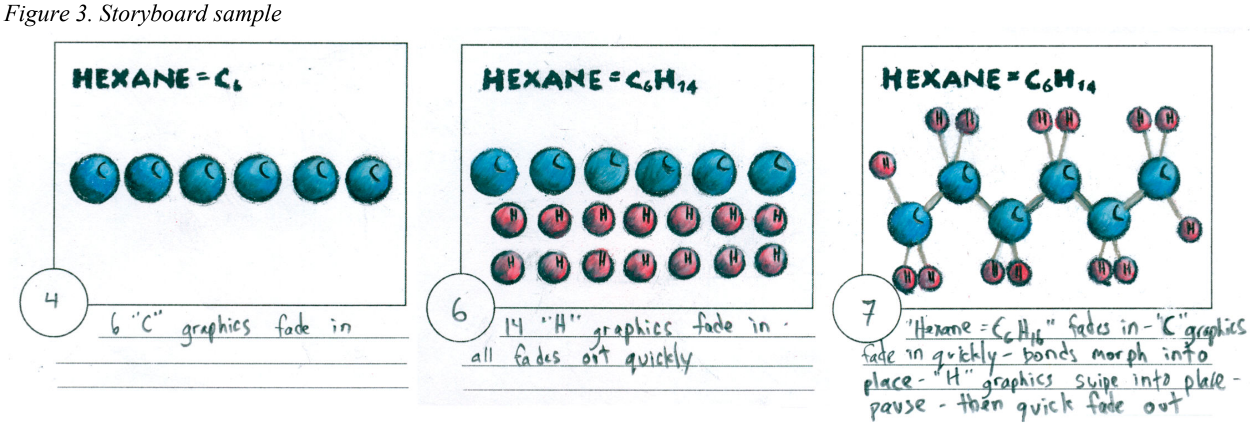
Video:
(1) The screen begins with a white stage.
HEXANE fades in location in the upper left hand portion of the screen.
(2) With HEXANE in place, an equals (=) sign will fade in to the right of the word
(3) "C_6" will fade in to the right of the equals (=) sign
(4) Six identically-sized blue carbon atoms, all in a single row, fade in under the incomplete equation and centered in alignment with the stage
(5) "H_{14}" fades in directly to the right of the "C_6" to complete the equation
(6) 14 red hydrogen atoms fade in beneath the larger carbon atoms in two evenly sized and spaced rows of seven. There is a pause and a fade to a white stage.
(7) On a clear white stage the equation fades into place. Following that the carbon atoms in their organic chemistry's representation of their actual form quickly fade into place. The bonds that connect the carbon atoms and those that will eventually connect the carbon atoms to the hydrogen atoms do a morph of thin to actual size, also quickly fading in.
(8) Concurrently with the bonds, the hydrogen atoms, in the representative of their form, swoop into place — shrinking from an enlarged expanded perspective to their final positions.
(9) Once the atoms are in place, the brightness is increased to make them appear to flash.

Design Phase III: The Sketching and Storyboarding Phase

Each student created a visual design of the script by mapping out conceptual ideas with pencil thumbnail sketches and rough sketches. Decisions of composition, typography and imagery were discussed. Before this could be completed, however, additional standards needed to be determined for the graphics, font, frames per second, and motion of the graphical elements. These were added to the design guidelines, which were stored online for easy access.

When the art director approved the rough pencil sketches, the sketches were made into visual color solutions using Prismacolor pencils in a process known as storyboarding, which is a visual representation of how the problem will be graphically solved. It captures the details and integrates the content. It makes the necessary decisions by describing the solution visually and describing the action verbally. The storyboards are an animation requirement, a communication tool, instructions, and a marketing tool for buy-in or approval. In other words, the living document was not only used as animation directions for the graphic technologist, but as a proof for the client and a sign-off to commence with the creation of the animation. The storyboards consisted of a set of actions that represent each key frame, displayed what the user sees, showed the sequence of events, and showed available navigation controls. The art director met with the client and the storyboards were approved.

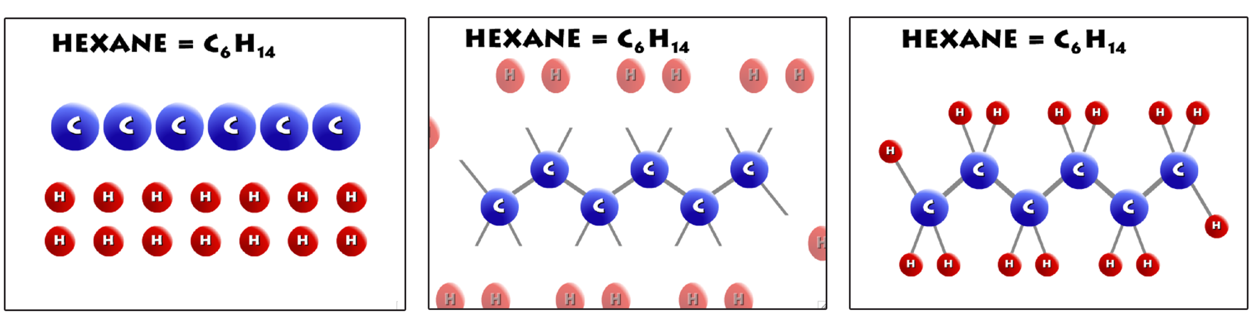
Figure 3. Storyboard sample



Design Phase IV: The Implementation Phase

The storyboards were the blueprint for design activity, and the molecular structures were implemented using Macromedia Flash, a vector-based animation software. The interface design was modified according to the standardization guidelines determined by the team. The project manager kept everyone on task, and had each person sign off as soon as his or her task was completed, making each team member accountable to each other. Individual success was determined by the success of the other team members, so it was in each person’s best interests that the other members completed the tasks.

Figure 4. Flash keyframe screen shot samples



Throughout this process, online tutorials were made available for the students, and in-class hands-on demonstrations were given for creative and technical content clarification. During this phase, students interacted actively with each other, often remaining two hours past the end of the class to complete the project.

Students have traditionally relied on the professor for answers. For this project the professor responded to questions in class by asking the students more questions, rather than giving packaged answers, such as: "Did you discuss this with the R&D person? Have you thought about …? What do you believe the next priority is in this project? Have you compared how other universities have solved this problem?" Students had to learn to be resourceful and rely on their own initiative, as well as on each other. This was somewhat stressful for students, until they realized that finding the answers was their responsibility.

V. Findings

Success indicators to the learner-centered project were demonstrated in the coalition-building and assessment of student achievement. The encouragement of responsibility for learning indicated that these student were well on their way to becoming lifelong learners. Because the average student age was in their early-20s, the students were mature enough for a student-initiated approach to learning, rather than relying on a traditional instructor-led approach.

Assessment Outcomes

Visual and technological literacy increased substantially during the semester. Based on the results of the pre- and post-tests, the students overall increased their score to 7.5 times that of the pre-test. Initially, all but one student failed all areas of the pre-test. One student passed the technical knowledge section, but did not pass the creative section. The pre-test scores did not count against the students. This assessment was only used to determine the level of their knowledge base at the beginning of the semester.

At the end of the semester, all students not only passed the post-test, but also scored an A or B. The creative knowledge base of multimedia design planning and storyboarding increased substantially. Knowledge was also gained in the technical knowledge base of the Flash technology through the application of multimedia skill sets.

Performance levels were analyzed by reviewing the individual animations, storyboards, sketches, scripts, and lab reports. The projects were of high quality and met the criteria of the standardization guidelines in a timely fashion.

The lifelong-learning skills were observable in the areas of teamwork, collaboration, client relations, standardization, and acceptance of responsibilities. Goals were reached through completion of learning objectives. By the end of the semester, the students had experienced a successful learner-centered activity. They learned decision-making through analysis of many choices. They learned to negotiate and research information. They developed people skills and formed a learning and knowledge community through learning to work with a diverse student population and learning to collaborate with each other. Through the process of project management, they learned to think strategically and successfully complete the tasks of threading technology with an interdisciplinary focus. The affective skills developed changed student attitude and the way the students perceived failure. They also realized that success is more obtainable if there is feedback, that mild anxiety is motivational, and that the amount of effort given to an activity is a direct indication of desire to learn.

The following are the findings in the areas of decision-making, people skills, project management, and social perceptions:

Decision-making Skills

Many Choices. The innovative use of multimedia learning objects included in the online curriculum provided a delivery consistent with learner-centered education goals by giving students many choices in learning methodology — from collaborative team work to individual reflection.

Student Decision Making. The students in the learner-centered activity contributed by (1) creating goals and objectives for the project, (2) assessing and monitoring their own progress, (3) establishing standardization guidelines to determine evaluation criteria, and (4) planning and being held responsible for the activity.

Learning to Negotiate. At one point the industrial technology professor added an unexpected task for the team — individual detailed lab reports. This was not in the initial requirements of the project. This was done intentionally in order to observe the response of the students. The project manager became concerned and relayed that concern to the professor. A healthy discussion pursued with the project manager. The students determined that with the time allocated, this was not going to be realistic. They negotiated for a couple more days to be added to the deadline. Another alternative they discussed was to meet the deadline without the report and turn in the report after the deadline. They had no problem doing the extra work. But since it was not in the list of tasks required at the beginning of the project, they negotiated successfully and learned to develop their higher order (metacognitive) skills.

Research and Discovery. Because most of the multimedia design planning content was organized around critical and creative thinking and problem solving, faculty and students were engaged in mutual discovery. New knowledge was continuously related to exisiting knowledge through discovery. Decisions about what knowledge was to be modified and added to the central standardization guideline was a continuous process.

An online supplement to the face-to-face GIT 314 course was accessible to the students in the class. This allowed for the accommodation of a variety of learning styles. It guaranteed students had available time to contribute to group discovery through online class discussion, as well as in class. The traditional lecture was not the prevalent mode of course delivery, but it was used to deliver academic content and assessment of procedures. Even though the least learning-centered format is the lecture, often a plethora of material must be covered, so the lecture format must be used on occasion. Presenting the content in an interesting manner was the challenge.

People Skills

People vs. Machines. Learning how to problem solve with people instead of machines was a new experience for most of the technologists. They discovered that people skills were necessary in the majority of the activities.

Forming a Learning and Knowledge Community. Because the students shared ideas and skills, a learning community was formed. The result was a positive working environment with increased personal relationships with each other. They worked hard together and became friends. "I have never had a class like this at ASU," one student exclaimed. "I have gotten to know other students in class and I don't want this to end."

The classroom environment in a successful learner-centered project should be a nurturing one. Eliminating the fear of failure helped the students take more risks, increase their motivation, and interact more frequently with each other. They felt like they "owned" the organic chemistry animation project and therefore took full responsibility for its success. The environment supported the individual student with varying learning styles, skills, and cultural backgrounds.

Student Diversity. Because of the diversity of the team members in technical, creative, presentation, and communication abilities, the students were forced to rely on each other.

Collaboration. The material was appropriate to the students' level. The students also learned that the client was the content provider and they had to take the information and determine how best to disseminate it to the target audience. Because of this, the students had to collaborate with others on the instructional tasks. They often stayed two hours after class was over interacting with each other in the lab and discussing how best to solve a problem. They learned to respect each person's contribution to the team.

Project Management Skills

Time Management. The coordination of multimedia content required a concerted commitment of time and energy to organize the activities around relevant themes and plan the teaching throughout the semester. The project manager created a timeline with slack time incorporated into it. His responsibility was to monitor the completion of the individual tasks and to determine if the deadline was going to be met. He constantly had to reassess the appropriateness of the deadlines.

Strategic Thinking. The students approached their learning experience as a way to solve an industrial problem. They not only had to learn the concept of the subject matter, but also develop their primative Flash skills. In other words, they had to become strategic thinkers by deciding what methods worked and what did not through observation and interaction with their team. The industrial technology professor helped to expand the learning outcomes by asking questions, not by giving them answers.

Technology Threading. Graphic skills development and graphic projects were integrated into all aspects of the learner-centered work and became academically linked to organic chemistry, demonstrating successful threading of technology and technological literacy.

Interdisciplinary Focus. Many students successfully master the course content in individual courses, but have a difficult time interconnecting the relationships between another discipline and technology. The traditional approach to curriculum usually does not integrate fields of study. The interdisciplinary approach demonstrated how multimedia can be threaded throughout all academic disciplines. It helped the student use their mind to "think outside of the box." The interdisciplinary multimedia project increased teamwork skills, creativity, student access to technology and created synergy between curricula in different departments.

Attitudinal Skills

The students in the case study learned to take 100 percent responsibility for their actions. If an event occurred, they found that the outcome was based on their response. Attitude was the one thing in which they agreed they had control over.

Learning Through Failure. The industrial technology professor had to facilitate the learning process by guiding the effective strategies of production and teamwork, such as concept mapping and categorizing. Occasionally the students were allowed to fail at a task in order to learn. An example was when the students interviewed the client and did not get the content they needed in order to do the animations. The students learned how important it is to guide and control the client interview in order to get the content needed to successfully complete the task. They learned that careful planning of questions ahead of time is necessary.

Ensuring Success Through Feedback. Reaching the goals of the project required the industrial technology professor to meet with students to ensure success and feedback, and continue with innovative connections. The students felt challenged to learn in order to reach the team goals. Because of the ongoing assessment of the design process, feedback from the professor was given on a continuous basis in the form of questions. The purpose of the classroom discussions was to discuss the expectations of learner-centered education in the course, develop networking, and create a focus group.

Mild Anxiety is Motivational. Curiosity, along with mild anxiety, propelled the performance and motivation of completing the project. Too much stress and worry about competence detracted from the learning process. When those moments came, the industrial technology professor stopped the process and gave the students a creative or technical demonstration and asked them questions. They got back on track. The tasks were novel enough to stimulate natural curiosity, difficult enough to create mild anxiety to learn to be competent, but reachable enough to succeed. This created intrinsic motivation to learn.

Effort. Effort is also a reaction to one's motivation to learn. Because the individual's work had to meet the standards determined by their team, peer pressure was the guiding force for individual accountability. The students perceived that the tasks were relevant to reaching the end goal and they held each other accountable.

VI. Conclusions

Because technology is socially, culturally, economically, and politically constructed by our society, technology changes the way in which people work, and subsequently changes our society. Present and future educators in higher education must learn to engage their students in learning-centered approaches to teaching, and use active learning styles to guide future industrial workers.

The active learning found in the team project, supported the design and testing of experimental models and strategies that led to learner-centered education. The activities sought to expand the pool of technically and visually literate people in our society by targeting GIT majors not typically portrayed as organic chemists, and have them learn how to apply their graphic technology knowledge to solve a team industrial problem. Shifting the pedagogy of traditional lecture-only environment to that of learner-centered education, can transform a classroom project into transferable learning, which effectively meets the needs of the student and of industry.

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