Using the ARCS Theory of Motivation as an Assessment for Self- Directed Learning

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Introduction

Successful educational efforts should be driven by theory (Bird and McClelland, 2010). When designing instruction, elements of theory need to be used as the basis for design and development of effective programs as well as the evaluation of such programs (Contento, 2001 as cited in Bird and McClelland, 2010). Franz (2007) states that "Learners should be directly involved in developing, implementing, and evaluating learning experiences to encourage critical reflection between teachers and learners, and realignment of programs." It follows here that the realignment of programs should be due to feedback provided by learners that the program or instruction was created for. In studies by Walberg et. al., it is stated that learner motivation can predict accomplishment of learning outcomes and that the amount or quality of instruction does not have a bearing on students achieving learning outcomes if motivation is low (Walberg, 1980, Walberg, Schiller, & Haertel, 1979 as cited in Nwagbara, 1993). In this study, the online curriculum developed, the Cow to Cup Series: An Interactive Tour of the Dairy Industry, was developed using Keller's ARCS Theory of Motivation to add motivational elements to the self-directed instruction to assist in motivating students during the learning experience.

Literature Review

Researchers have developed slightly different definitions of motivation (Wlodkowski, 1985, Arkes & Garske, 1982, Martin & Briggs, 1986 as cited in Nwagbara, 1993). For example, Wlodkowski (1985) states that motivation is "those processes that can: (a) arouse and instigate behavior, (b) give direction or purpose to behavior, (c) allow behavior to persist, and (d) lead to choosing or preferring a particular behavior." According to Wlodkowski's (1985) definition,

there are two pivotal pieces to motivation: behavior and persistence. Keller (1983) states that motivation also is the degree of effort a person exerts to a specific task. Gagne (1985), states that the conditions that influence motivation can be "both internal and external" to the learner (as cited in Nwagbara, 1993). The conditions that influence motivation internally, as defined by Gagne (1985), are any skills or knowledge that the learner has about the content before the learner approaches the instruction. The conditions that influence motivation externally are experiences that learner is afforded through the instruction (Gagne, 1985). In fact, several educators have determined that learner motivation is a factor that cannot be ignored in the design and development of instruction (Briggs, 1977, Keller, 1983b, Gagne, 1985, Wlodkowski, 1985, Mayer, 2014 as cited in Nwagbara, 1993).

Keller's ARCS Model of Motivational Design and DeCharms' Personal Causation Model, are based in social learning theory and expectancy value theory (Keller, 1979, DeCharms, 1968 as cited in Nwagbara, 1993). These two specific models focus more on external factors to the learner, such as environmental factors and factors related to the task of learning, and their relationship to the personal values and abilities of the learner (Nwagbara, 1993). One of these factors is the instruction itself. Before Keller developed the ARCS Theory of Motivation, the other models that had come before him to address motivation to learn failed to address that the instruction itself might actually motivate the learner to learn.

Methodology

In this study, the self-directed learning curriculum, consisting of four modules, "The Cow to Cup Series: An Educational Tour of the Dairy Industry," consisting of four modules, was assessed. This curriculum was designed using John Keller's ARCS Theory of Motivation. The acronym here stands for the four pieces of Keller's theory (Attention, Relevance, Confidence and Satisfaction). The researcher recruited classrooms/teachers for this study through a University sponsored High School Agriculture Teachers Workshop where teachers could indicate their interest. Eight schools indicated interest in this way and due to the time period chosen for data collection only two schools were able to participate. Two other schools were contacted directly when this event produced insufficient numbers of students. One hundred sixty-five participants were recruited for this study. Some were not involved in analyses due to missing information. Agriculture teachers were asked to provide classroom instruction time to the researcher for up to five days (teachers chose which of their classes and how many modules were used) and administer pre- knowledge tests to students before they interacted with the instruction. During the classroom time, students used their school-provided laptop or tablet to interact with the instruction during the class period. Following this, half of the students in each classroom took a post-knowledge test which assessed knowledge after instruction and the other half submitted the survey instrument assessing motivation for each module (Table 1).

Table 1.

Assessment Protocol

Module	Students with Odd Numbers (i.e. 3001)	Students with Even Numbers (i.e. 3002)
Breeding and Genetics	Post- Knowledge Test	Affective Motivation Survey
Product Production	Affective Motivation Survey	Post-Knowledge Test
Product Processing	Affective Motivation Survey	Post-Knowledge Test
Grocery Store	Post-Knowledge Test	Affective Motivation Survey

One school opted to only complete one module (Product Production), have all of their students take the pre-test and post-test, and half of the students take the motivation survey per the protocol above for Product Production module.

Table 2.

Concepts covered in the "Cow to Cup: An Educational Tour of the Dairy Industry" modules

Breeding and Genetics	**Milk Production**	**Milk Processing**	**Grocery Store**
Punnett squares and phenotypes	Fertilization, gestation, parturition	Milk transport to processor	Carbohydrates, proteins, fats, vitamins and minerals
How genetics play a role in the farmer's decisions	Female anatomy	Milk storage	Food sources that are examples of each nutrient
	Detecting parturition	Cream and milk label percents	Nutrition facts label
	Calf care and colostrum	Homogenization, pasteurization, UHT (Ultra-High Temperature Pasteurization)	Lactose intolerance vs. milk allergy
	Puberty/sexual maturity	Milk safety and bacteria	Milk brands: Fairlife and Lactaid
	Milking process	Inventors of processing steps	Substitutes for the nutritional value of 8 ozs of lowfat milk
	On-farm milk storage	Chemical vs. Physical processes done to milk	
		Sell-by dates, milk tracing, milk bottling	

Instrumentation

Each of the four modules had a different knowledge test, due to different content in each (Table 2), but the pre-test and post-test were identical. The knowledge tests were a combination of multiple choice questions, fill-in the blank, short essay and select all that apply questions. The instrument that was used to assess affective motivation was minimally adapted from Huang and Hew's (2016) article. This instrument consisted of 35 questions with a Likert agree or disagree scale to assess the four parts of Keller's ARCS Theory of Motivation. The research questions for this study are described and paired with the appropriate statistical test in Table 3.

Table 3.

Research Questions and Statistical Tests Used

Research Questions	Data Set	Analysis	Statistical Test Used
1. Do the Cow to Cup Series educational modules increase content knowledge related to the dairy industry?	School 1, 2, 3, 4	Pre-test vs. Post-test	Paired T-Test
2. Is there a relationship between content knowledge related to the dairy industry and affective motivation score after completing a Cow to Cup Series educational module?	School 3	• CK score* vs. Overall Mean AMS* • CK score vs. Attention, Relevance, Confidence and Satisfaction mean of the module	Chi Square Test
3. Is there a relationship between the *a priori* content knowledge related to the dairy industry score and affective motivation score after completing a Cow to Cup Series educational module?	School 1, 2, 3, 4	• Pre-test score on each module vs. Overall Mean AMS on each module • Pre-test score vs. Attention, Relevance, Confidence and Satisfaction Mean of the module on each of the four modules	Correlation
**Note:* AMS- Affective Motivation Score; CK- Content Knowledge Gain (Post-test minus Pre-test)			

Results

1. Do the Cow to Cup Series educational modules increase content knowledge related to the dairy industry?

Students viewing the modules had an overall increase in content knowledge (P<.05). This result is displayed in two different ways in the following tables. Table 3 shows the overall points possible in the columns labeled “Score Ranges.” Student tests were graded in such a way that every answer that was correct received plus one point and every answer that was incorrect received minus one point, which explains the negative end of the score ranges. The column labeled “Student Score Ranges” delineates the range of scores that students actually achieved on each test (Table 4). This table also holds the mean score on each test and corresponding standard deviation (Table 4).

Table 4.

Descriptive Statistics of Student Knowledge Scores

					Score Ranges		Student Ranges		
Module	Test Type	N	Mean	SD	Min Possible Score	Max Possible Score	Min Score	Max Score	P value
1	Pre-Test	44	22.9	13.3	-40	40	-26	36	0.005
	Post-Test	44	28.3	8.5	-40	40	-5	38	
2	Pre-Test	92	-3.3	7.8	-48	36	-16.5	26.5	0.000
	Post-Test	92	10.9	10.0	-48	36	-9.5	32	
3	Pre-Test	49	7.4	8.4	-55	34	-14	22	0.000
	Post-Test	49	16.4	11.1	-55	34	-11.5	33	
4	Pre-Test	44	10.1	3.5	0	19	0	18.5	0.000

	Post-Test	44	13.6	3.9	0	19	5.5	19	

In Table 4, significance values between the pre- and post-tests show that there was a statistically significant difference in the scores on the pre and post-tests. The direction of this change is evidenced by the mean scores on each test shown in Table 3. Students demonstrated through their scores on the post-test that there was an increase in content knowledge immediately after viewing the educational module in all four modules. Mean increases for Module 1, 2, 3, and 4 total 5.4, 14.2, 9.0, and 3.5 points respectively.

2: Is there a relationship between content knowledge related to the dairy industry and affective motivation score after completing a Cow to Cup Series educational module?

When determining if there was a relationship between content knowledge and affective motivation score no significant relationships were found. This data was collected on only a subset of the population, school #3 (N= 18). The class time available in the other participating schools only allowed for either the post-test, or the motivation survey, to be administered. This is a limitation of the study, however, this information is valuable to have to analyze the design of the modules. This group of students (N) was too small to perform a correlation.. There is evidence that no relationship exists between knowledge gain and the mean of attention items (p=.269), mean of relevance items (p=.291), mean of confidence items (p=.326), mean of satisfaction items (p=.145), or the mean of the overall ARCS survey items (p=.255).

3: Is there a relationship between the *a priori* content knowledge related to the dairy industry score and affective motivation score after completing a Cow to Cup Series educational module?

At the .05 significance level, there is evidence that a relationship does not exist between *a priori* content knowledge on any of the four modules related to the dairy industry and the mean of attention items, mean of relevance items, mean of confidence items, mean of satisfaction items, or the mean of the overall ARCS survey items on that module.

Summary

- Youth scores on pre and post knowledge tests for Module 1, Module 2, Module 3, and Module 4 demonstrate that there was a significant knowledge increase immediately following the intervention (curriculum) because of the intervention/ curriculum.
- There was no statistically significant evidence that there was a relationship between how much knowledge a student gained and their perception of the ARCS Theory of Motivation components within the instruction.

- There was no statistically significant evidence that a student's *a priori* content knowledge had a relationship with their perception of the ARCS Theory of Motivation components within the instruction.

Discussion

The findings of this research indicate that the curriculum, when presented to high-school aged students in the context of a formal classroom environment, elicited a significant increase ($p<.05$) in content knowledge across the entirety of the curriculum. This builds a strong case that students can learn from self-directed instruction like this and, in fact, are very much capable of doing so. However, during the collection of the data in this research, the researcher encountered several students that stated that they were confused when learning from materials without a teacher telling them what needed to be learned.. Regardless of the students' familiarity with the type of instruction, they demonstrated that the curriculum was effective in increasing content knowledge.

There was no relationship in this population of high school students between knowledge gain and affective motivation score, which is contrary to the findings in several other studies (Walberg, 1980, Walberg, Schiller, & Haertel, 1979 as cited in Nwagbara, 1993). Further research with high school students would help to determine if this is as anomaly, or if high school students are different than the older learners in the studies cited.

Recommendations

- This curriculum increases student knowledge about the dairy industry, and various components of the industry. It could be used for 'e-learning days' or as a supplemental assignment in a variety of agricultural classes.
- This curriculum could be used with students in an informal education setting, such as 4-H, and findings should be garnered about this group's perceptions of the instruction's capacity to: gain and keep the learner's attention, show relevance of the material to be learned, instill confidence in the learner, and leave the learner satisfied with the learning experience.
- Further research should be conducted using the ARCS model to develop instructional modules for high school students, to determine the most effective ways to develop materials that stimulate student motivation to learn.

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submitted pictures of their farm operations, or personified the characters in the modules. Without the help of these people and the funds from the USDA-SPECA grant that funded the development of the curriculum in this study, this research would not have been possible.

Recommendations for Further Reading

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Cow to Cup: An Interactive Tour of the Dairy Industry
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Abstract

This article discusses the implementation and evaluation of a unit of self-directed curriculum that aims to teach high-school students in a formal classroom setting about the dairy industry. The evaluation included a 35-question survey which garnered feedback about the self-directed learning (SDL) experience and pre- and post-knowledge tests. Students demonstrated content knowledge gain; however, the students demonstrated low affective motivation on the instrument. Educators implementing self-directed curriculum should be confident in the ability of SDL experiences to increase content knowledge and afford students more SDL experiences to increase familiarity with this method of learning in the classroom.