THE DEVELOPMENT OF AN ARCS GAMING SCALE

Exploratory factor analysis was used to determine the factor structure of the ARCS Gaming Scale, a modification of Keller's Instructional Motivational Scale. The ARCS Gaming Scale was designed to measure the components and degree of motivation produced by the use of computer games. The ARCS Gaming Scale is composed of 36 items with nine items representing each of four major constructs or categories (i.e., attention, relevance, confidence, and satisfaction). Thirty-six items on the total instrument were evaluated to see if the factors of attention, relevance, confidence, and satisfaction emerged. The data for this study was collected over a two-year period with 40 adult subjects playing five games from a pool of 40 games. Results suggest limited support of some aspects of the ARCS Gaming Scale, particularly in measuring attention or interest. Implications for use of the ARCS model as a motivational measure for instructional gaming are discussed.

Background

One of the most frequently-employed methods of designing motivational strategies into instruction designs is John Keller's ARCS model. Keller perceives of the ARCS model as a problem-solving approach which helps instructional designers identify and solve motivational problems related to the appeal of the instruction (Keller, 1983, 1985). In practice, the ARCS model is often used as a framework which helps designers address motivational strategies in much the same way Gagne's Nine Events of Instruction (Gagne, Briggs, & Wager, 1992) is used to assure the systematic inclusion of instructional strategies. In actuality, these models are often used in conjunction.

The model is based in a number of descriptive motivational theories including attribution theory, reinforcement theory, and achievement theory. The core support for the ARCS model, however, is expectancy-value theory (e.g., Porter & Lawler, 1968). Keller sees a learner's expectancies (an individual's subjective probability of success) and values (the satisfaction of personal needs or motives) as key determinants of effort which in turn influences performance the resultant consequences (1979).

The model has for major components attention (which Keller originally referred to as interest), relevance, confidence (originally referred to as expectancy), and satisfaction. These components, in turn, have 3 subcomponents each. These are described in figure 1. Keller views attention and relevance as representing a major division of the value component of expectancy-value theory. The third component, confidence, is seen as corresponding to the variables subsumed under expectancy. In Keller's view, the final component, satisfaction, incorporates "both intrinsic and extrinsic motivational factors" (1996, p. 171).
The literature has focused on prescriptive practical applications of the the ARCS model for purposes of instructional development (e.g., Buckley & Marovitz, 1989; Keller, 1987a, 1987b; Keller & Kopp, 1987; Keller & Suzuki, 1988; Suzuki, 1993). A few efforts, however, have been made in validation of the model (e.g., Small & Gluck, 1994; Visser & Keller, 1990). As the model can be viewed as a framework instead of a procedure for instructional development, the limited amount of research studies to validate it is understandable. After all, the motivational elements in Keller's model (values, expectancy, and motivational design and management) are posited to directly influence effort, not performance (Keller, 1979). Where performance can be defined as actual accomplishment, effort, by contrast, can be thought of as the degree to which an individual engaged in exertions resulting in accomplishment. Some of an individual's exertions (thinking, for example) are often covert and therefore more difficult to study.

Given the popularity of the ARCS model for developing motivational strategies, it is not surprising that efforts have been made to use the constructs of the model for measuring motivation in instructional materials. The focal point of these labors has been an instrument developed by Keller himself, the Instructional Materials Motivational Scale or IMMS (Keller, 1987). The IMMS has been used in several published studies.

Klein and Keller (1990) used the confidence-related questions on the scale to measure a student's confidence after using a set of instructional materials. The internal consistency reliability estimates of this subscale was reported at .77.

The entire IMMS was used by Klein and Freitag (1991) to measure student perceptions of the motivational characteristics of the instructional materials used in their study. They reported Cronbach's alpha reliability of the instrument to be .89 for attention, .81 for relevance, .90 for confidence, .92 for satisfaction, and .96 overall.

The scale has also been adapted in at least two other research studies. Small and Ferreira (1994) modified the IMMS to make a scale called the Information Resource Attitude Survey. This scale was said to assess subjects' motivation toward using a specific information resource (i.e., an interactive videodisc or a book). The overall reliability for this instrument was reported to be .95.

Two closely-related ARCS scales were modified by Bohlin, Milheim, and Viechnicki (1993). One was titled the Course Interest Survey Revised (CISR) and the second the Course Effort Survey Revised (CESR). The 42-item scales differed only in asking subjects to rate the importance of each of 42 strategies on their own interest or effort, respectively. Reliability of the scales was not reported. The purpose of the scales were to "identify the instructional motivation needs of learners." Factor analyses showed some support for the CESR, but not for the CISR.

The ARCS Gaming Scale discussed in this paper is a modification of Keller's Instructional Materials Motivational Scale (Keller, 1987d). The scale includes statements related to attention, relevance, confidence, and satisfaction specifically oriented toward computer gaming.

Method
The data used in this study was collected over a two-year period and was collected along with a more extensive, primarily qualitative, observations of 40 simple computer games (Dempsey, Lucassen, Haynes, & Casey (1997). The primary focus of original study was to probe for components or structures of existing computer games that would lend themselves for use in an educational or instructional setting. Specifically, we wished to identify, primarily through observations and questionnaires, those attributes that were either motivating or distracting to adult players and to determine if these attributes tended to vary because of the age or gender of the player.

Eight categories of computer games with five games per category (total 40 games) were chosen for the study. The games chosen were originally intended to be entertaining, not instructional although a primary selection criteria for all included games was that each must have some identifiable potential for educational use, if adapted. Each category was comprised of five games serving as a sampling of the variety of games found in each area. Each game was played by two females and two males. Ten packets containing four games each was randomly assigned to the 40 volunteers (160 observations).

Forty adults, 20 females and 20 males, participated in the study. Ages of participants ranged from 18 to 52. All volunteered to participate. Educational achievement was rather evenly divided among high school, college, masters, and doctoral degreeed individuals. Most were moderately to very experienced using computers. A majority of subjects reported that they enjoyed playing games.

Instrument

The ARCS Gaming Scale was designed to measure the components and degree of motivation produced by the use of computer games. The Gaming Scale is composed of 36 items with nine items representing each of the four major constructs or categories (i.e., attention, relevance, confidence, and satisfaction). The estimated reliability of the scale was .6371. Each of the four major constructs is subdivided in to three subcategories. Three items were included for each of the 12 subcategories. Items 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, and 36 were phrased in reverse (negative) direction to help prevent response sets from occurring. The major and subcategories, and the key questions associated with them, are listed in Figure 1.

Statistical Analysis

Exploratory factor analysis was used to determine the factor structure of the ARCS Gaming Scale. More specifically, the 36 items on the total instrument were evaluated to see if the factors of attention, relevance, confidence, and satisfaction emerged. We wanted to determine how well the ARCS Gaming Scale followed the ARCS theory. According to ARCS theory, each major category (A, R, C and S) is further divided into three subcategories (Figure 1). Therefore, each set of nine items (there were three items for each subcategory) was also factor analyzed to determine if the subcategories emerged as predicted. Principle Components analysis was used for component extraction. The components were rotated using the Varimax procedure. All analyses were conducted using SPSS for Windows, Version 7.1.
Results

Analysis of Total Scale

The Bartlett's test of sphericity was highly significant (p<.0001) resulting in the rejection of the null hypothesis that the correlation matrix is an identity matrix. Therefore, the variables are significantly intercorrelated. The first factor is clearly the attention category of the ARCS model. All nine of the attention items had high loadings on factor one. Items 3, 6, 9, and 15 had negative loadings because of reverse wording. The only non-attention item loading on factor one was Q15, a relevance item.

The second factor is labeled relevance. The majority of the relevance items (5 of 9) loaded most strongly on this factor. In addition, three satisfaction items (items 29, 31, and 32) loaded on factor two. The third factor is labeled satisfaction/confidence because six of nine satisfaction items loaded on it and five of nine confidence items loaded on it. At least with this scale, the Keller's satisfaction and confidence categories are closely related. The fourth factor is labeled confidence/relevance because four of the nine confidence items loaded on it and 3 of the nine relevance items loaded on it. Apparently confidence and relevance are also related.

At least two of the three subcategory items, for all of the subcategories, loaded on one of the four factors. The following subcategories loaded on factor one: perceptual arousal, inquiry arousal, and variability. For factor two, the subcategories were motive matching and familiarity (relevance subcategories), and positive consequences (a satisfaction subcategory). It appears that these three subcategories are closely related. For factor three, the subcategories were success opportunities and personal growth (confidence subcategories), and natural consequences and equity (satisfaction subcategories). It appears that these four subcategories are related. Finally, the factor four subcategories were goal orientation (a relevance subcategory) and learning requirements (a confidence subcategory). These components of relevance and confidence are closely related.

Analysis of Subcategories

Nine questions were written for each of the four ARCS categories. In the subcategory analysis, each of the four sets of questions were factor analyzed to determine if the predicted subfactors would emerge. The first nine questions were the Attention items specifically written to measure the attention subcategories of perceptual arousal, inquiry arousal, and variability. For factor two, the subcategories were motive matching and familiarity (relevance subcategories), and positive consequences (a satisfaction subcategory). It appears that these three subcategories are closely related. For factor three, the subcategories were success opportunities and personal growth (confidence subcategories), and natural consequences and equity (satisfaction subcategories). It appears that these four subcategories are related. Finally, the factor four subcategories were goal orientation (a relevance subcategory) and learning requirements (a confidence subcategory). These components of relevance and confidence are closely related.

The rotated factor matrix for the second set of nine items was written to measure the subcategories of relevance, specifically including goal orientation, motive matching, and familiarity. Three principle components accounted for 63.9 percent of the variance, and, again, Bartlett's test of sphericity was highly significant (p<.0001). All three subcategories emerged as was predicted according to ARCS theory. Factor one was labeled inquiry arousal, factor two was labeled perceptual arousal, and factor three was labeled variability.

The rotated factor matrix for the second set of nine items was written to measure the subcategories of relevance, specifically including goal orientation, motive matching, and familiarity. Three principle components accounted for 63.9 percent of the variance, and, again, Bartlett's test of sphericity was highly significant (p<.0001). Factor one is composed of two familiarity items and two motive matching items. These items appear to be tapping into the same underlying construct, Factor two includes the three goal orientation items. Factor three includes one motive matching and one
familiarity item. The familiarity item also loaded on factor one which is probably predominately a familiarity factor. However, familiarity and motive matching are clearly related.

The rotated factor matrix for the third set of items was written to measure the subcategories of confidence, specifically including learning requirements, success opportunities, and personal control. Three principle components accounted for 71.7 percent of the variance, and, Bartlett's test of sphericity was highly significant (p<.0001). Factor one is composed of all three personal control items and one success opportunities item. The factor is labeled personal control. The second factor includes all three of the learning requirements items and one success opportunities item. The factor is labeled success opportunities. The third factor has a single loading on one success opportunities item. Based on this analysis the three success opportunities items do not form a single construct and two of the items (Q23 and Q24) load on other subcategories.

The rotated factor matrix for the fourth set of items was written to measure the subcategories of satisfaction, specifically including natural consequences, positive consequences, and equity. Three principle components accounted for 75.6 percent of the variance, and, Bartlett's test of sphericity was highly significant (p<.0001). The first factor includes two positive consequences items and two natural consequences items. Thus, the consequences subcategories are not clearly distinguishable. Factor two is composed of two equity items. The third factor includes one positive consequences item, one natural consequences item, and one equity item.

Discussion

The results provide limited evidence in support of using some aspects or items of the ARCS Gaming Scale. Factor 1 matched well with the attention (or interest) component of Keller's model. Factor 2 less loaded strongly on relevance. It is interesting to note that, according to Keller (1979), these two components represent a major division of the value component of expectancy-value theory. Confidence (the expectancy component of the expectancy-value theory) loaded both on factors 3 (with satisfaction) and 4 (with relevance).

As Keller and his associates have pointed out (Keller, 1983, 1985; Keller, Kelly, & Dodge, 1978) it is very difficult to measure the important elements which influence motivational design. Among the most powerful elements are human characteristics, design strategies, social and environmental conditions, and consequences (Keller, 1985). Although some direct measures (e.g., time-on-task or latency of response) can be useful, these may also be misleading and situation dependant. Also, the 40 games used as the materials of this study were highly diverse and that would naturally affect the reliability of the instrument and, to some extent, the overall findings. In addition, although they were selected because they had some potential for educational use, the games were not primarily designed to be entertaining, not instructional.

It appears from the results of this study that some components and subcomponents of the ARCS model may never neatly factor analyze, probably because of correlated items across the various scales and subscales. Its usefulness as a motivational measure therefore may be limited. Does this mean the ARCS model is highly flawed? Our response is absolutely not! As a practical framework
for designing instructional motivational strategies, the ARCS model has proven its worth time and again. It is taught in many graduate instructional design programs around the world, including our own. Its has had a very positive influence on the routine practice of our craft. The results may suggest, however, that we may not easily place the square pegs of motivational design heuristics into the round holes of measurable motivational components.

(n1) The complete ARCS Gaming Scale, correlation matrices, and factorial solutions can be found by contacting the senior author at the Department of Behavioral Studies and Educational Technology, 3700 UCOM, University of South Alabama, Mobile, AL 36688 or may be downloaded as COE Technical Report 98-2 at http://www.coe.usouthal.edu/techReports/notes.html.

Figure 1. Major Categories and Subcategories of Keller's ARCS Model[*]
Legend for Chart:

A - Major Category
B - Subcategory
C - Questions

A

B

C

1. Attention

Perceptual Arousal
What can I do to capture their interest?

Inquiry Arousal
How can I stimulate an attitude of inquiry?

Variability
How can I maintain their attention?

2. Relevance

Goal Orientation
How can I best meet my learner's needs? (Do I know their needs?)

Motive Matching
How and when can I provide my learners with appropriate choices, responsibilities, and influences?

Familiarity
How can I tie the instruction to the learners' experiences?
3. Confidence

Learning Requirements  How can I assist in building a positive expectation for success?

Success Opportunities  How will the learning experience support or enhance the students' beliefs in their competence?

Personal Control  How will the learners clearly know their success is based upon their efforts and abilities?

4. Satisfaction

Natural Consequences  How can I provide meaningful opportunities for learners to use their newly-acquired knowledge/skill?

Positive Consequences  What will provide reinforcement to the learners' successes?

Equity  How can I assist the students in anchoring a positive feeling about their accomplishments?

[*] Adapted from Tables 3-5, Keller, 1987.

References


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