

Knowledge Area Module V:
A Framework for the Pedagogical Evaluation of
Video Game-Based Learning Environments

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Abstract

Currently, there is no framework for the pedagogical evaluation of video game-based learning. A host of research issues have emerged to create the next generation of games to support learning in math, science, and engineering. Yet little to no research has emerged in the area of game-based learning to improve the combat readiness of the armed forces. This paper explores, compares, contrasts, and synthesizes prevailing learning design theories from such noted learning experts as Gagne, Bloom, Kirkpatrick and Keller with video game design theories in order to create an evaluation framework for video game-based learning. It adds definitive research in the badly needed area of military game-based learning that the Department of Defense needs that proves, or disproves, the idea that digital game-based learning can improve individual, or collective, performance in the field.

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ADULT LEARNING THEORY

Currently, there is no framework for the pedagogical evaluation of video game-based learning. A host of research issues have emerged to create the next generation of games to support learning in math, science, and engineering. Yet little to no research has emerged in the area of game-based learning to improve the combat readiness of the armed forces. This paper is designed to explore, compare, contrast, and synthesize prevailing learning design theories from such noted learning experts as Gagne, Bloom, Kirkpatrick and Keller with video game design theories in order to create an evaluation framework for video game-based learning. The objective is to add definitive research in the badly needed area of military game-based learning. The Department of Defense needs research that proves, or disproves, the idea that digital game-based learning can improve individual, or collective, performance in the field. This project will fill one of the many areas of research needed by creating an evaluation framework of video game-based learning. It will be created through the kind of thought leadership arrived at through scholarly research which emphasizes analysis, synthesis and critical thinking.

As an educational tool, gaming simulation has been around for thousands of years, with the depiction of strategic military problems in games like Chess. In modern times, the use of flight simulators to train pilots and astronauts is a highly developed example. Other examples include business gaming such as the Top Management Decision Simulation, developed by the American Management Association in the 1950s

(Coppard, 1976). From the late 1950s to the mid-1960s gaming simulations appeared in political science and international affairs, and the field of urban planning.

An early example of computer assisted instruction was a system called PLAN (Weisgerber, 1971). This system was used in schools throughout the United States in the mid-1970s. In this system, the computer kept records about each student's previous study, progress, and performance. Teachers received daily reports on completion of lesson objectives as well as activities started or completed by each student. Periodic student progress reports were also generated. The information in the computer database was used to help plan individualized learning activities.

Early examples of computer-based instruction (CBI), even those that included some variation resulting from user control, such as limited branching, tended to be designed in such a way that everyone received basically the same program. A better approach is to incorporate adaptive motivational conditions which reflect the changes in a student's motivation over time (Keller, 1999).

Today, gaming simulation applications can be found in almost every field. Coppard suggests, "some of the most appropriate games are not found in one's own field, but instead were developed for another purpose and may be easily adapted to similar applications in a different field." (Coppard, 1976, p. 40-2) For more on the design process for gaming simulations, see Coppard (1976, pp. 40-9 to 40-13). For a detailed technical

consideration of the game design process, see *A Guide for Simulation Design*, by Adair and Foster (1972).

Pedagogy Versus Andragogy

Malcolm S. Knowles (1980) coined the faux-Greek term “andragogy” (sometimes spelled “androgogy”) to distinguish teaching practices specifically aimed at adult learners from those used to teach young people in primary and secondary education. Knowles theory of andragogy assumes that adults (1) want to know why they need to learn something (although this would seem to apply to adolescents as well), (2) need to learn experientially, (3) approach learning as problem-solving, and (4) learn best when the subject is of immediate value. Furthermore, adults tend to be self-directed and expect to take responsibility for decisions that affect them.

E-learning courses based on the principles of androgogy ask the questions: What do you want to learn? How and when do you want to learn? (Islam, K., 2002). Adult learners process information differently from their youthful counterparts. Nevertheless, the assumptions for adult learners can in many cases be reasonably applied to young people when discussing video game-based learning systems.

Brookfield (1986) says that adult learners:

- Are not beginners, but are in a continual state of growth;
- Bring with them a package of experiences and values, each one unique;

- Come to education with intentions;
- Bring expectations about the learning process;
- Have competing interests; and
- Already have their own set patterns of learning.

Adult learning is therefore most productive when:

- Learners are engaged in the design of learning;
- Learners are encouraged to be self-directed;
- Educators function as facilitators rather than didactic instructors;
- The individual learners' needs and learning styles are taken into account;
- A climate conducive to learning is established;
- The learner's past experiences are used in the learning process; and
- Learning activities seem to have some relevance to the learners' circumstances.

Gagné's Nine Events of Learning

Gagné defines instruction as “a set of events external to the learner designed to support the internal processes of learning” (Gagné, 1977, 1985). Proceeding from this definition, he has formulated nine instructional events which relate to internal learning processes. These are summarized in the following table (Table 1):

| <i>Instructional Event</i> | <i>Relation to Learning Process</i> |
|------------------------------------------|-------------------------------------------------|
| 1. Gain attention | <i>Reception</i> of patterns of neural impulses |
| 2. Inform learner of the objective | Activates a process of <i>executive control</i> |
| 3. Stimulate recall of previous learning | <i>Retrieval</i> of prior learning to working |

| | |
|---------------------------------------|------------------------------------------------------------------|
| 4. Present the material | memory |
| 5. Provide learning guidance | Emphasize features for <i>selective perception</i> |
| 6. Elicit performance (practice) | <i>Semantic encoding</i> ; cues for retrieval |
| 7. Provide feedback about performance | Activate <i>response organization</i> |
| 8. Assess the performance | Establish <i>reinforcement</i> |
| 9. Enhance retention and transfer | Activate <i>retrieval</i> , making <i>reinforcement</i> possible |
| | Provide cues and strategies for <i>retrieval</i> |

Table 1: Gagné's Nine Events Of Learning

Five different purposes for evaluation of student performance are:

1. **Student Placement.** Tests are administered in order to identify an appropriate starting point for instruction.
2. **Diagnosis of Difficulties.** Tests can indicate areas in which a student needs remedial instruction for earlier skills that have not been mastered, making it difficult to learn material that builds upon those skills. Remedial instruction may require the use of different methods and materials.
3. **Checking Student Progress.** Routine tests to check student progress may be used less often when students appear to be progressing consistently well. Such progress checking may need to be used more often when students are experiencing difficulties.
4. **Reports to Parents or Supervisors.** In addition to the function of supplying reassurance that the learner is progressing well, accumulated assessment results may provide a basis for promotion, certification or other benefits.
5. **Evaluation of the Instruction.** Instruction methods can be evaluated with overall scores as well as evaluation of individual items. A common evaluation process

(particularly applicable to computer-based instruction) is formative evaluation, in which a series of tryouts and revisions result in improved effectiveness.

The various types of individualized instruction can differ substantially from traditional classroom instruction. Adult learners can benefit from materials and procedures that are less highly structured than those used for younger students.

Keller's ARCS Model

In an article summarizing the research upon which his ARCS Model is based and giving examples of actual use of the system, Keller notes that “no matter how motivated learners are when they begin a course, it is not too difficult to bore them, if not kill their interest totally” (1987, pg. 2). The ARCS Model consists of four conceptual categories related to human motivation as well as a set of specific strategies (see Tables 1-4, Keller, 1987, pp. 4-5) which may be used to improve the general motivational aspects of a course of study. It also makes use of Keller’s process called motivational design.

Expectancy-value theory, based on the work of Tolman (1932) and Lewin (1938), provides the foundation of ARCS. “Expectancy-value theory assumes that people are motivated to engage in an activity if it is perceived to be linked to the satisfaction of personal needs (the value aspect), and if there is a positive expectancy for success (the expectancy aspect)” (Keller, 1987, pp. 2-3). Keller separated “value” into two categories: “interest,” which refers to attention-related issues, and “relevance,” which refers to

matters of perceived benefit and usefulness. He added a category for “outcomes” to cover the application of applied reinforcement and environmental outcomes that contribute to intrinsic motivation. Interest, relevance, expectancy and outcomes subsequently became attention, relevance, confidence and satisfaction respectively, giving rise to the acronym ARCS.

Attention — Many simple techniques can be used to get attention, but the difficulty lies in sustaining attention. “The goal is to find a balance between boredom and indifference versus hyperactivity and anxiety” (Keller, 1987, p. 3).

Relevance — Perceived relevance with regard to schoolwork or future career goals may or may not be present intrinsically in a given course of study. Keller holds that a perception of relevance can come from the method of instruction, whether or not it is inherent in the content.

Confidence — Whether one succeeds or not, regardless of external factors or innate ability, depends to a great degree on one’s feelings of confidence in the possibility of success. This can particularly affect a student’s persistence. Keller points out that “fear of failure is often stronger in students than teachers realize” (Keller, 1987, p. 5). The Confidence strategies offered by ARCS are designed to help create the impression that some degree of success is possible given an appropriate effort on the part of the learner. Keller cautions, however, that it is important to “avoid creating this impression if it is false,” thereby setting up unrealistic expectations.

Satisfaction — According to operant conditioning theory, the definition of task and reward, together with an appropriate reinforcement schedule, should cause people to be more motivated. A problem can arise if the use of these techniques is perceived to intrude on the student's rightful sphere of control. This is particularly likely to happen when the activities in question are those from which the student derives intrinsic satisfaction. "A challenge is to provide appropriate contingencies without over controlling, and to encourage the development of intrinsic satisfaction" (Keller, 1987, p. 6).

The ARCS Model incorporates a systematic seven-step approach to the design process (Keller, 1997) which has been revised and refined based on further study (see Keller, 1999). This process can be summarized as define, design, develop, and evaluate. According to Keller, it is appropriate to use the ARCS Model "if the problem is one of improving the motivation appeal of instruction for a given audience" (Keller, 1987, p. 6).

A point which may be particularly relevant to video game-based learning is that, for students who have a high degree of initial motivation, overuse of motivational strategies can actually interfere with the instructional objectives.

In the evolution of the ARCS process, a simplified design strategy was developed (Suzuki and Keller, 1996; Keller, 1997). This process has been utilized successfully in studies in several different countries, suggesting a multicultural validity. The process is

presented in a two-dimensional matrix with the ARCS categories on the horizontal axis, and specific design factors on the vertical axis (see Table 4.1, Keller, 1999, p. 41).

A principle application of this system is to identify areas in which motivational strategies are appropriate. As mentioned earlier, overuse of motivational strategies can interfere with a student's intrinsic interest in a subject. The motivational design process requires an audience analysis to decide which motivational tactics are appropriate. Keller points out, "Learner motivation changes over time, however, and sometimes in unpredictable ways" (1999, p. 42). According to Keller, "When students are motivated to learn, they want to work on highly task-relevant activities. They do not want to be distracted with unnecessary motivational activities. For this reason it would be nice to have computer or multimedia software that can sense a learner's motivation level and respond adaptively."

Song (1998) developed an approach to motivationally adaptive CBI. At predetermined points in the instructional program, a screen was presented which asked questions pertaining to the students' motivational attitudes. The responses in conjunction with actual performance levels were used to personalize motivational tactics for each student.

Another variation relevant to CBI concerns the motivational problems faced by distance learners. These students must overcome feelings of isolation, feelings associated with a lack of evidence of steady progress, and doubts about their ability to complete the

material. Visser (1998) used a variation of the ARCS approach to address these problems. Her approach, which dealt with traditional distance learning materials, could be adapted to CBI and video game-based learning. She sent messages in the form of greeting cards to students according to two parallel schedules. The first schedule was based on specific points in the course and the messages were the same for all students. The second schedule consisted of personalized messages sent at times that were deemed appropriate based on the student's performance.

Bloom's Taxonomy

Benjamin S. Bloom of the University of Chicago headed a group of distinguished academics who, in a series of conferences held from 1949 to 1953, set out to develop a taxonomy, or classification system, to be used in working with educational objectives and outcomes. The first volume of the work, subtitled Handbook 1: Cognitive Domain, was published in 1956. A second volume covering the affective domain was published in 1964. The primary focus of this work was to aid college-level instructors analyzing test items. "The major purpose in constructing a taxonomy of educational objectives is to facilitate communication," Bloom says (1956, p. 10). This would enable those involved with educational research, curriculum development and testing to "compare and exchange tests and other evaluative devices intended to determine the effectiveness of these programs." In deciding how to proceed with the construction of the taxonomy, Bloom states, "We are of the opinion that although the objectives and test materials and techniques may be specified in an almost unlimited number of ways, the student

behaviors involved in these objectives can be represented by a relatively small number of classes” (1956, p. 12).

The classification system presented in this work has been widely accepted throughout the educational system, though several alternatives and revisions have been presented. Bloom’s Taxonomy, as it is commonly known, is considered hierarchical, ordered in terms of increasing complexity, and consists of the following categories and sub-categories:

Cognitive Domain: Knowledge

- 1.00 Knowledge
 - 1.10 Knowledge of Specifics
 - 1.11 Knowledge of Terminology
 - 1.12 Knowledge of Specific Facts
 - 1.20 Knowledge of Ways and Means of Dealing with Specifics
 - 1.21 Knowledge of Conventions
 - 1.22 Knowledge of Trends and Sequences
 - 1.23 Knowledge of Classifications and Categories
 - 1.24 Knowledge of Criteria
 - 1.25 Knowledge of Methodology
 - 1.30 Knowledge of the Universals and Abstractions in a Field
 - 1.31 Knowledge of Principles and Generalizations
 - 1.32 Knowledge of Theories and Structures

Cognitive Domain: Intellectual Abilities and Skills

- 2.00 Comprehension
 - 2.10 Translation
 - 2.20 Interpretation
 - 2.30 Extrapolation
- 3.00 Application
- 4.00 Analysis
 - 4.10 Analysis of Elements
 - 4.20 Analysis of Relationships
 - 4.30 Analysis of Organizational Principles
- 5.00 Synthesis
 - 5.10 Production of a Unique Communication
 - 5.20 Production of a Plan, or Proposed Set of Operations

- 5.30 Derivation of a Set of Abstract Relations
- 6.00 Evaluation
 - 6.10 Judgments in Terms of Internal Evidence
 - 6.20 Judgments in Terms of External Criteria

Bloom's *Handbook* contains many specific examples of test items illustrating each subcategory of the taxonomy. Testing of the various stages of learning incorporate these general principles:

Knowledge — When testing a student's ability to recognize or cite accurate statements, the form of the question and the level of precision required should not differ significantly from the way the knowledge was initially learned.

Translation — This is the ability to convert the learned material into other words. When testing this stage of learning, Bloom notes, "If the evaluation is to be of a behavior transcending knowledge, the context in which the terms or symbols appear must be to some extent novel context" (Bloom, 1956, p. 97).

Interpretation — Testing a student's ability to interpret learned material can be done either with a question requiring an essay type response, multiple-choice selections, classifying items relative to the material presented, or questions as to whether the data presented is sufficient to prove the truth or falsity of given statements. Exercises of this last type may either ask for an evaluation based solely on the information presented, or may utilize the given data as well as other knowledge the student may possess.

Extrapolation — Exercises testing extrapolation, often used in conjunction with Interpretation, “attempt to determine whether or not the student can go beyond the limits of the data or information given and make correct applications and extensions of the data or information” (Bloom, 1956, p. 117).

Application — When a student’s ability to apply learning is to be tested, the situations presented “must either be situations new to the student or situations containing new elements as compared to the situation in which the abstraction was learned” (Bloom, 1956, p. 125). When testing effect of instruction on application ability, it is necessary to differentiate between solutions based on general problem-solving ability and solutions that are the result of instruction. One can make this determination by testing individuals who are equal in general ability to those who are the target of the application items, but who have not received the instruction in question. It is important for purposes of evaluation to distinguish between inability to apply and inability to comprehend. This can be done by testing the degree of the student’s comprehension of the situation before the application items are attempted. When accurate knowledge of the problem-solving process employed by the student is required, actual recording of the steps taken by the student (an operation particularly suited to computer-based systems) is preferable to attempts to infer the process from the construction of the test items. Bloom notes that “students can come up with ways of arriving at answers, often correct, that no teacher seems to have anticipated” (Bloom, 1956, p. 127).

Analysis — In discussing Analysis, Bloom indicates a variant of the hierarchy of the published taxonomy which is adopted by Anderson and Krathwohl in their revised version. Bloom writes, “No entirely clear lines can be drawn between analysis and comprehension at one end or between analysis and evaluation at the other” (Bloom, 1956, p. 144). This statement and the subsequent discussion omit the Synthesis classification, which in the Handbook is placed between Analysis and Evaluation. Anderson and Krathwohl (2001) reverse the order of the elements corresponding to Synthesis (Create) and Evaluation (Evaluate).

Bloom further divides Analysis into the ability to classify “elements” of the material, specifying the “relationships” among the elements, and recognition of “organizational principles” of arrangement and structure (Bloom, 1956, p. 145). Testing the student’s ability to analyze material is most effective when the material to be analyzed is presented in the test situation, as opposed to relying on the student’s familiarity with it. While student answers may be free-form or guided responses, selecting the best answers in multiple-choice format offers the advantage of structuring items to include common errors.

Synthesis — Synthesis is defined as combining elements in order to form a whole. (Compare to Anderson and Krathwohl’s “Create”) “This is a process of working with elements, parts, etc., and combining them in such a way as to constitute a pattern or structure not clearly there before” (Bloom, 1956, p. 162). Bloom’s subcategories of Synthesis are distinguished “primarily on the basis of product” (p. 163). These products

may be a “unique communication” of some form, the purpose of which is “to inform, to describe, to persuade, to impress, or to entertain.” The second subcategory consists of “a plan or proposed set of operations.” Items in this subcategory are distinguished from the previous subcategory in that they are incomplete until translated into action. The product of Synthesis in the final subcategory is “a set of abstract relations.” Here the distinguishing factor is that the relations “are not explicit from the start; they must be discovered or deduced” (p. 164).

Testing for Synthesis is made more difficult by the necessity of providing conditions favorable to creative output — primarily freedom. “The student should be made to feel that the product of his efforts need not conform to the views of the instructor, or the community, or some other authority, if such freedom is otherwise consistent with the nature of the task” (Bloom, 1956, p. 173). Evaluation of Synthesis poses formidable problems because of the lack of objective criteria to be used. The idiosyncratic nature of creative output can make judgment, even by experts, appear arbitrary. Bloom addresses this issue to a degree by indicating that a synthesis can be considered faulty because it fails to fit the requirements of the problem.

Table 2 summarizes Bloom’s Taxonomy of Learning.

| | |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Evaluation | appraise, argue, assess, attach, choose compare, defend estimate, judge, predict, rate, core, select, support, value, evaluate |
| Synthesis | arrange, assemble, collect, compose, construct, create, design, develop, formulate, manage, organize, plan, prepare, propose, set up, write |
| Analysis | analyze, appraise, calculate, categorize, compare, contrast, criticize, differentiate, distinguish, examine, experiment, question, test |
| Application | apply, choose, demonstrate, dramatize, employ, illustrate, interpret, operate, practice, schedule, sketch, solve, use, write |
| Comprehension | classify, describe, discuss, explain, express, identify, indicate, locate, recognize, report, restate, review, select, translate |

| | |
|------------------|--------------------------------------------------------------------------------------------------------------------|
| Knowledge | arrange, define, duplicate, label, list, memorize, name, order, recognize, relate, recall, repeat, reproduce state |
|------------------|--------------------------------------------------------------------------------------------------------------------|

Table 2: Bloom's Taxonomy of Learning

Bloom's original Taxonomy has been revised utilizing advances in education theory since its original publication (Anderson and Krathwohl, 2001). The revised version was changed to focus on a broader audience, especially elementary and secondary teachers. One fundamental change was to replace the noun forms of the classifications used in the Handbook with verb forms. "Verbs of the kind used by teachers in statements of objectives and during instruction seemed more helpful in framing and categorizing objectives, instructional activities, and assessment tasks" (Anderson and Krathwohl, 2001, p. 307). These verb forms (as illustrated in Table 2) are distinguished as "Cognitive Processes" and are used to form a separate dimension for analysis. The reorganized and renamed noun forms making up the original "Knowledge" category and sub-categories became another dimension, called the "Knowledge Dimension." Table 3 shows a simplified version of this new, multi-dimensional framework.

| The Knowledge Dimension | The Cognitive Process Dimension | | | | | |
|---------------------------------|---------------------------------|-------------------|--------------|----------------|-----------------|---------------|
| | Remember | Understand | Apply | Analyze | Evaluate | Create |
| Knowledge | | | | | | |
| Conceptual Knowledge | | | | | | |
| Procedural Knowledge | | | | | | |
| Meta-cognitive Knowledge | | | | | | |

Table 3: The Knowledge Domain

The simplest activities (i.e., remembering facts) are in the upper left of the table, and complexity increases as we move down and to the right. The categories of the Knowledge Dimension and the Cognitive Process Dimension are further divided into subcategories for classification purposes (Anderson & Krathwohl, 2001; Krathwohl, 2002). As noted above, the order of “Evaluate” and “Create” are reversed from their corresponding categories in the original Bloom Taxonomy (“Synthesis” and “Evaluation”). This ordering, while not without some difference of opinion, arises in part from an analysis of empirical evidence and a decision to order the categories from most simple to most complex. “Simply stated, induction, which is involved in Creating, is a more complex process than deduction.” (Anderson and Krathwohl, 2001, p. 294)

The new category of Metacognitive Knowledge is defined as “Knowledge of cognition in general as well as awareness and knowledge of one’s own cognition.” (Anderson and Krathwohl, 2001, p. 29) This category in the revised taxonomy is of increasing significance as research shows how being made aware of their metacognitive activity can help students adapt the ways they think and approach learning activities (Krathwohl, 2002).

The Taxonomy Table, derived from the two-dimensional representation of the Knowledge (noun) and Cognitive Process (verb) components, provides a concise representation for classifying objectives, activities and assessments. By plotting course objectives on the table grid, for example, one can easily see the extent to which more complex kinds of knowledge and cognitive processes are represented. Blank spaces on

the grid suggest what might have been included but wasn't. This helps to identify opportunities to enhance the course objectives (Krathwohl, D. R., 2002).

The ADDIE Model of Design

The ADDIE Model of instructional system development (ISD) seems to have evolved informally rather than being the product of a single author. ADDIE is an acronym for Analysis (or Assessment), Design, Development, Implementation, and Evaluation. Molenda (2003) traces the origins of the ADDIE acronym, which appears to be an afterthought of various related descriptions of ISD concepts. One of the earliest antecedents to ADDIE appears to be a report by Branson (1978) of a model developed in conjunction with the U.S. military called the Interservice Procedures for Instructional Systems Development (IPISD). Branson provides a graphic labeled "Analyze, Design, Develop, Implement, and Control." The model is not, however, referenced by the acronym ADDIC.

Thiagarajan (1976) is sometimes cited as the originator of the ADDIE label, but he refers only to A-D-E in his work.

ADDIE begins to appear in the late 1980s in a variety of sources with no clear attribution. According to Molenda, "It is only in the recent literature that the term is beginning to take on a more fully elaborated meaning. However, these authors are

essentially creating their own interpretations as there does not appear to be an original, authoritative version of ‘the ADDIE Model’ ” (2003, p.4).

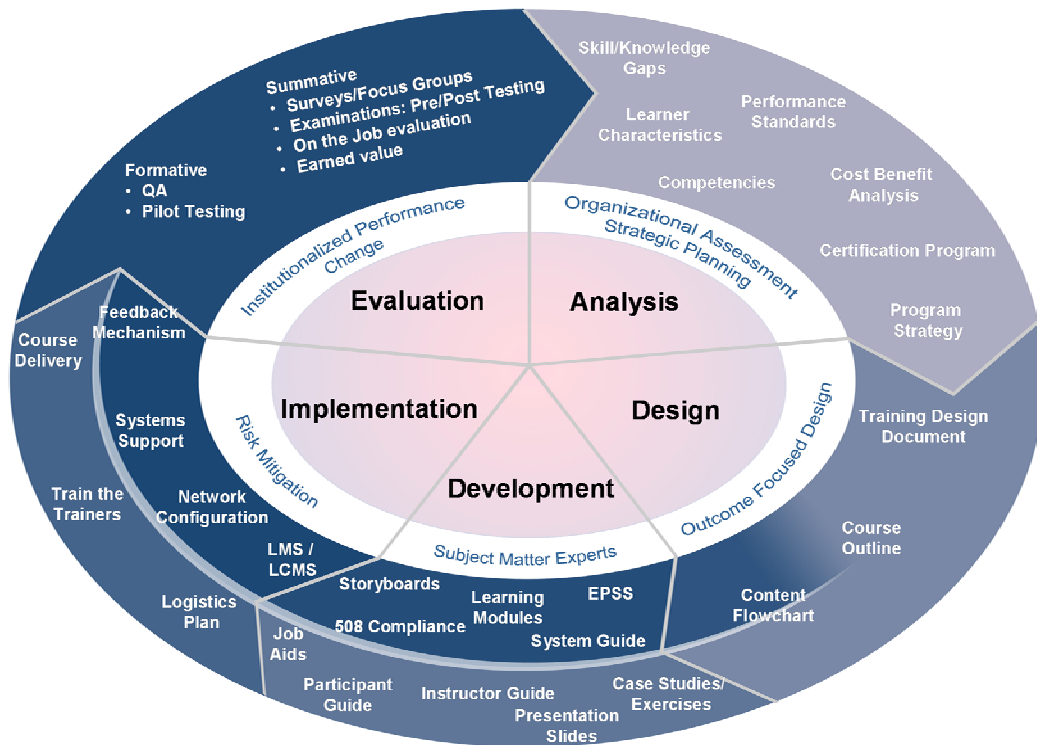


Figure 1: ADDIE Model of Instructional Design

Kirkpatrick Evaluation Levels

Kirkpatrick’s system of evaluation has been widely used in the area of professional training for over 40 years. This system consists of four steps or levels of increasing complexity. Kirkpatrick’s four levels can be summarized as follows:

Level 1 — Reaction. This level, which is the easiest to test for, represents the feelings of the learners about the training received. A variety of testing examples show a

familiar series of questions where the student is asked to rate various aspects of the training on some kind of quantitative scale. While most questions are given in an objective form, some space is generally allowed for additional comments not addressed by the other questions. Kirkpatrick emphasizes that this level of evaluation “does not include a measurement of any learning that takes place” (Kirkpatrick, 1976, p. 18-2).

Level 2 — Learning. Kirkpatrick defines learning in this context as “the principles, facts, and skills which were understood and absorbed by the conferees” (Kirkpatrick, 1976, p. 18-11). In other words, the learning he describes corresponds to Bloom’s (1956) Knowledge category and subcategories. Kirkpatrick recommends that this level of evaluation include before-and-after testing as well as a control group when possible in order to assess the actual impact of the training, the use of objective questions to provide quantifiable data which can then be subjected to a statistical analysis.

Level 3 — Behavior (also called Transfer). At this evaluation level, the focus is on behavioral changes that are brought about by the learning which has presumably taken place. Kirkpatrick saw this as a way to quantify the common knowledge that there is often “a big difference between knowing principles and techniques and using them” (Kirkpatrick, 1976, p. 18-16). Here again, the use of before-and-after testing, a control group, and statistical analysis are recommended. In addition, he suggests appraisal by persons other than the individual being evaluated to aid in the objectivity of the results. He also recommends a post-training appraisal three months or more after the training has

been completed in order to assess the lasting effect of behavioral changes resulting from the training.

Level 4 — Results. This is the most vague of Kirkpatrick's levels. The desired results can vary greatly from one type of training program to another, and therefore the testing to determine the degree to which those results have been met vary as well. For this reason, in the context of job-related training, Kirkpatrick suggests that evaluations focus on the first three levels. "From an evaluation standpoint, it would be best to evaluate training programs directly in terms of results desired. There are, however, so many complicating factors that it is extremely difficult, if not impossible, to evaluate certain kinds of programs in terms of results. Therefore, it is recommended that training directors evaluate in terms of reaction, learning, and behavior" (Kirkpatrick, 1976, p. 18-21).

Kirkpatrick's evaluation levels have been widely accepted in industrial and organizational environments. "The power of Kirkpatrick's model is its simplicity and its ability to help people think about training evaluation criteria" (Alliger & Janak, 1989, p.331).

Three assumptions associated with Kirkpatrick's system are "implicit in the minds of researchers and trainers, although to all appearances unintended by Kirkpatrick himself when the model was proposed" (Alliger & Janak, 1989, p.332). These assumptions are: (1) Levels are hierarchical, with each providing more information than the last, (2) There is a causal relationship between each successive level, and (3) There is a positive

correlation between levels. The authors challenge the validity of these assumptions with a detailed analysis of the available literature.

Evaluation of training using the Kirkpatrick system can suffer if care is not taken to define needs and resources or to determine how the results will be applied. Problems can occur if the system comes to shape the questions and results. Emphasis on return on investment (ROI) in a business context tends to skew evaluation. Measurements based mainly on financial indicators focus on past performance and encourage a short-term strategic view (Abernathy, 1999).

It can be useful to divide results into categories of “hard data” and “soft data” (Phillips, 1996). Hard data, the kind traditionally used to evaluate performance, includes things such as output (units produced, tasks completed, etc.), quality (waste, defects, etc.), time (project completion time, overtime, etc.), and cost (overhead, variable costs, etc.). Soft data are more subjective and harder to assign a monetary value. This includes work habits (punctuality, safety, etc.), work climate (grievances, job satisfaction, etc.), attitudes (loyalty, perception of responsibilities, etc.), new skills (decisions made, conflicts avoided, etc.), development (promotions, performance ratings, etc.), and initiative (implementation of new ideas, employee suggestions, etc.).

“How do we value training that has tangible results versus that which has intangible results?” Abernathy asks. “Should we try to measure it?” Abernathy quotes Fred Nickols, executive director of strategic planning and management services at the

Educational Testing Service as saying, “The best measure of anything, including training, is sometimes gauged by its absence. Only when it is absent does its value dawn on those who take it for granted” (1999, p.22).

Kaplan and Norton (1992) offer a scorecard method that seeks to balance business management by measuring performance across four perspectives: finance, customers, internal business processes, and learning and growth. “The learning and growth perspective directs attention to the basis of all future success” (Abernathy, 1999, p. 21).

VIDEO GAME DESIGN THEORY

A half a century ago, video games came to life. On large television screens, man discovered that technology could be fun. The video game industry has changed drastically since then, morphing into one of the biggest and most popular entertainment forms in the world. Video games have thrived, overcoming early criticism as being nothing more than a fad, emerging as the preeminent popular art form of the 21st century.

As a form of entertainment, video games engage us emotionally, can hold even the most distracted teen's attention and even help adults learn. Video gaming is the most popular form of entertainment today and this popularity has spawned many books on the subject. In his book, *Trigger Happy: Videogames and the Entertainment Revolution*, Poole (2000) states that, "according to the European Leisure Software Association, the British videogame software market already grosses 60 percent more than total movie box office receipts and 80 percent more than movie rentals" (p6).

Video games are more than just fun, they are art, and science mixed together. Many people have tried to dismiss video games as a passing fancy or for techno geeks without a social life. However, there are many who take video gaming seriously. By reading about, discussing and, even playing games, it is possible to gain a better understanding video game design theories in order to create an evaluation framework for video game-based learning.

Video Game History

Videogames have certainly changed the face of gaming yet the world of video games continues to evolve. But, where did it all begin? The history of video games is not just about people. It's also about inventions, dreams and companies.

Pre- Technology

Video gaming, in its earliest form, dates back to 1889 when Fusajiro Yamauchi established the Marufuku Company to manufacture and distribute Hanafuda, Japanese playing cards. In 1907, Marufuku began manufacturing Western playing cards. The company changed its name to The Nintendo Playing Card Company in 1951 (“The History of Video Games” 2001; Herz 1997).

In America, a key development in the game industry occurred in 1945 when Harold Matson and Elliot Handler began producing picture frames in their garage workshop. They come up with the name “Mattel” by combining letters from their names. In 1952, A.S. Douglas created the first graphical computer game - a version of Tic-Tac-Toe. In 1954, a former US Korean War veteran named David Rosen started Service Company Games to export coin operated machine games to Japan. Over the next decade, Rosen began to create his own coin-operated games, and SEGA, is born (“The History of Video Games” 2001; Herz 1997).

Perhaps the most well known bit of pre-technology history occurred in 1961, when Spacewar was created by then student Steve Russell. Spacewar was the first interactive computer game, originally built on a Digital PDP-1 (Programmed Data Processor-1) mini computer. Limited by the computer technology of the time, Spacewar utilized new teletype terminals with Cathode Ray Tube (CRT) screens to display the primitive graphics (“The History of Video Games” 2001; Herz 1997).

A few years after this, Nolan Bushnell and Ralph Baer entered the picture. Ralph Baer, originally tasked with creating a deluxe and modern television set, expanded on his idea for a secondary use for them. He began studying and researching interactive television gaming and was able to get his employer interested enough to fund his efforts. Eventually, Ralph Baer and his team succeeded in creating an interactive game that could be played on a television screen. They developed a chase game and followed it up with a video tennis game. This same team also modified a plastic toy gun so that it could ‘shoot’ dots on the television screen. These games were patented in 1968 and licensed by Magnavox in 1970. This game was called the Odyssey. Magnavox displayed the Odyssey at a convention in Burlingame, California, on May 24. A few years later, Magnavox began selling the Odyssey exclusively through its own stores, selling a modest 100,000 units (“The History of Video Games” 2001; Herz 1997).

During this same time period, Nolan Bushnell successfully created an arcade version of Spacewar, called Computer Space. Computer Space did not sell well. Shortly after, Bushnell left the company and started Atari in 1972. The newly formed Atari’s first

game was Pong, which was extremely successful. In 1976, Nolan Bushnell sold Atari to Warner Communications for \$28 million. He remained with Atari as chairman of the board (“The History of Video Games” 2001; Herz 1997).

In 1978, Atari released the Video Console System (VCS). The combination joystick and addle controllers were an instant hit, though disputes over money caused several Atari programmers to leave Atari, and form Activision in 1979. Emboldened by Atari's success, several companies began to release home video game consoles including Coleco's Telstar. Bally released a programmable console called the Bally Professional Arcade. In 1980, Mattel Electronics introduced the Intellivision game console. The next year, Nintendo released Othello, an arcade cocktail-table game based on the board game Othello. That same year, Midway, a Japanese company, began importing Space Invaders from Taito. Colecovision debuted in 1982. In 1993 people spent 22 billion dollars in arcades and video games [made by Atari and their competitors] (“The History of Video Games” 2001; Herz 1997; Saltzman 2004).

The video game industry continued to evolve and in 1986, Nintendo released the Nintendo Entertainment System (NES). The system debuted with Super Mario Bros., an arcade conversion, which became an instant hit. Coleco, however, soon filed for bankruptcy, with most of its catalog goes to Milton Bradley and Parker Brothers (“The History of Video Games” 2001; Herz 1997).

Video games popularity increased demand for portable machines or handheld devices on which the games could be played. The video games were cumbersome, and not easily portable. The manufacturers recognized this demand, and Nintendo released its handheld Game Boy. Atari also tried to get into the handheld game but, its attempt, the Lynx, was a failure (“The History of Video Games” 2001).

Post- Technology

In the 1990’s the major players were Nintendo, Sega, Sony, Hasbro and eventually, Microsoft. Atari was never able to return to its early glory. Nintendo remained at the head of the pack, releasing Super Mario 3, the all-time best-selling video game. Sega continued to turn out games to trade on its established arcade successes (“The History of Video Games” 2001).

Video game popularity had become so ingrained in popular culture and everyday life, that even Congress began to take notice. Outraged by the violence in Mortal Kombat and Night Trap, Senators Joseph Lieberman (Connecticut) and Herbert Kohl (Wisconsin) launched a Senate investigation into video game violence which led to an industry-wide rating system. In 1994, The Entertainment Software Rating Board (ESRB) was established to rate video games. Large letter icons began to appear on game boxes to let consumers know the recommended age of players for each game and whether the game is violent or sexual in nature. By the end of 1997, most software featured ratings on its packaging (“The History of Video Games” 2001).

In 1998, a newly formed development company headed by former Activision veterans announced that it would publish new games. Sony released the PlayStation and it was a success. The N64 is released in United States and Nintendo announced that Pokémon will be coming to the United States. Not to be undone, Microsoft entered the video game market with the XBox and Nintendo's Game Cube was released. At the end of the 1990's and early new millennium, cellular phone games entered the market, creating the third medium with which video games could be played (the first two being on a television screen and online). Today, video games are everywhere ("The History of Video Games" 2001; Herz 1997; Mencher 2002).

Gaming Theory

Wolf and Perron (2003) have written that "game theory seems to be teetering on a threshold: Many academics want to see game theory establish itself as predominantly academic discipline, while others seek to broaden the conversation between game designers, consumers, journalists and scholars" (p 26).

According to Rollings and Adams (2003), "game design is the process of: Imagining a game. Defining the way it works. Describing the elements that make up the game (conceptual, functional, artistic, and others). Transmitting that information to the team that will build the game" (p 4). Designing video games is a daunting task. But how do you turn an idea for a game into a game design? What qualities must the game

contain? Most game designers are game players themselves. To answer these questions, one must look to the experts or game designers, such as Chris Crawford, Andrew Rollings and Ernest Adams.

Chris Crawford

Chris Crawford started his career with the top name in the industry, Atari, in 1979 where he worked under Alan Kay as a manager of games research. He has published fourteen computer games and five books. He is the founder of Game Developers Conference (GDC), and is an expert in interactive story telling.

Crawford (2003) advises “Game design is not at all the same as game programming” (p2). He advises all ambitious would-be game designers to get an education and learn as much as they possibly can. Why? Because video games are an extension of life, and ourselves; to keep others attention and entertain them, it is important to know how humans interact with each other and the subconscious stimuli that influence them. Chris Crawford’s approach is interesting in that it encompasses a great deal of psychology as well as biological and physiological considerations. Crawford (2003) even pays attention to the subtlest of influences, as “most games have some subconscious element of mythology to them; you should understand the basic forces at work” (p131).

One of the more radical parts of his gaming theory involves taking up dangerous or exciting hobbies and adventure to create memories for the game. Learning how your own body reacts under pressure, to fear, to anticipation is important. One cannot put into a game or describe what one has not experienced. Including these experiences into a game will help create a realistic, engaging video game. He also suggests growing as a person, putting yourself in unfamiliar social situations and being creative as an essential experience for game creation (Crawford 2003).

Also important to Chris is communication. He feels that video games are a medium of communication; therefore, game designers must understand communication and human language. Humans communicate in order to share knowledge and experiences. Chris maintains that games are a form of entertainment, not art. It is this “fun factor” that makes gaming a unique expression (Crawford 2003).

Andrew Rollings and Ernest Adams

Ernest Adams is a member of the International Hobo design consortium. He developed a wide variety of games including games for the Sony Playstation. Ernest Adams has worked as a technical consultant spanning the games industry and the financial industry since 1995.

According to Rollings and Adams, their approach to game creation is that video game design is neither art nor science, but something in between. The goal of a game

design is entertainment; therefore, designing a game requires both creativity and science. Their game theory focuses on core mechanics, interactivity, and storytelling. Core mechanics are the rules that define the operation of the game world. It is this area that they advise more focus, as it can make the difference between a lackluster game and a truly great one. Interactivity is defining what the player will see, hear, react and behave in the game (Rollings & Adams 2003).

Storytelling is just that, telling a story that unfolds as the game is played or simply adds to the drama of the game. A game must have a goal, or a reason for the player to be playing the game. It also details where the player will go in the game, encounter, win, etc. Narrative is another part of telling a story. It simply means that part of the story that is told by the author and designer to the player. Without an intriguing story for the player to become emotionally involved in the game- whether by competitiveness or curiosity, etc - the game simply will not engage the player, failing to reach its goal (Rollings & Adams 2003).

Video Game Genres

Like people, not all video games are the same. Games are designed to appeal to both genders, different age groups and to achieve separate goals. Though different, games may share the same characteristics, and can be classified into the same category or genre. Genre is defined in the Webster's dictionary (2004) as "A category of artistic composition, as in music or literature, marked by a distinctive style, form, or content."

There are several video game genres, including Action, Adventure, Fighting, Puzzle, Role-playing, Simulation, Sports and Strategy games.

Action Games

An action game or “twitch” game is one that focuses on hand-eye coordination under pressure and reaction time. The majority of arcade games are action games. Action games usually have a lot going on at the same time, forcing the player to multi-task and make split second decisions. Popular backgrounds and themes for action games involve shooters, fighting games, non-shooters, driving games, war games and rescue missions. Some examples of popular action games are Mortal Kombat and Street Fighter Action. They are available in both 2D and 3D graphic modes (Herz, 1997).

Shooter games focus on the actions of a type of weapon, usually a gun. This type of game covers the majority of action games. Fighting games are games that involve two players who fight each other. These games can be played in single player (allowing one person to play against the computer) or multi-player (two players against one another) modes. Non-shooter games do not have the violence associated with shooter games and usually focus on fantasy or adventure type scenarios (Herz, 1997; Rollings & Adams 2003).

Action games, as with action movies, are usually popular with the male demographic, however, exceptions do exist. One good example of this is Asteroids,

which was immensely popular with women and girls. Some common elements of action games are lives, reaction tests, and hand-eye coordination tests (Herz, 1997; Rollings & Adams 2003).

Role Playing Games

Computer role-playing games are games in which the players acts out a fantasy or story within the game. Role playing games should improve with experience and contain strong storylines. Ideally, the player will become emotionally invested in the game due to the story line and characterization of the player and game world. Some examples of role playing games are Neverwinter Nights and Elder Scrolls III: Morrowind. A new trend that is being seen today in computer role playing games are manual game editors, which allow the player to edit the game as they wish to enhance their enjoyment, make the game more interesting, and increase their investment in the drama (Rollins & Adams 2003; Herz, 1997).

Simulation games

Simulation games are just that – they simulate actions, behaviors or environments. Simulation games are designed to place the player in the cockpit or drivers seat, as applicable, and depict what would be seen, felt or experienced by that individual if their actions were to occur in real life. Some examples of different types of simulation games are driving games and flight simulators. These games are first person, and may include

physical elements of the simulation, including a game shaped like a car or plane, jarring with shooting or turns, and sound effects (Bates 2002; Herz 1997).

Some types of the simulation games are used to give the player the experience of driving a car or flying a plane, and therefore offer extraordinary training benefits. This type of simulation game is heavily used in the military. Other games involve game play, point systems and victory conditions. Racing simulators are a popular arcade type of simulation game. The object of these games is to win a race without crashing (Herz, 1997).

Sports games

Sports games are immensely popular today, especially with men and boys. There are games for almost every sport, including bass fishing, golf and soccer. Sports games are often endorsed by famous athletes or celebrities, and they have become multi-million dollar ventures. Sports games are designed to depict an actual game, play and the game's surroundings. These games will be set in stadiums, basketball courts, and even 'street' basketball courts. The settings are usually sports specific, can be very detailed, and include announcers, cheerleaders, coaches and fans (Bates, 2002; Rollings & Adams, 2003).

Sports games should be written with a complete and detailed set of rules, including special situations and exceptions. Though some games such as football or

basketball may be played multiplayer, they can be played single player or computer against the computer (demo mode). Characterizations of the players have become more detailed with personalities that show responses to anger, jubilation, frustration and even egos. Popular sports games include Madden NFL, ESPN Basketball, and Athens 2004 (Bates, 2002; Rollings & Adams, 2003; Herz, 1997).

Strategy games

There are basically two types of strategy games – classic and consolidation of power games, also known as war games. Examples of classic games are chess, scrabble or hearts. This type of strategy game is depicted as an electronic version of a board game. The games playing board is on screen and the players are represented as game pieces. Strategy games must be well written to include a complete set of rules and exceptions for game play.

Other types of strategy games are war games, or “god games”, where the strategy involved is complex decision-making directed at conquering a kingdom or country. Examples of this type of game are Risk and Battle Chess. These games award points for decisions made, and the ultimate goal is to gain power or win the war. The player must decide turn-based strategy based upon changing criteria and factors. Strategy games can be played out many different ways, and are played at a slow rate of pace. These games can be played single or dual player mode (Bates, 2002; Rollings & Adams 2003; Herz, 1997).

Puzzle games

Puzzle games involve a set of obstacles that must be overcome to “win” the game. One of the most popular puzzle games is Tetris. Most puzzle games cannot be won, however, and are played for fun or to accumulate points.

Adventure games

Adventure games include the immensely popular Legend of Zelda. This type of game involves accumulating items in order to solve puzzles and accumulate points to win the game. The goal of this type of game is pick up useful items which help the player move on to the next level, getting the player closer to the ultimate goal which may be a rescue scenario or similar mission. Bates (2002) advises “players generally expect an adventure game to have a large, complex world to explore, along with interesting characters and a good story (p9).

Video Game Design

Video game design has changed tremendously over the years. It has gone from a single programmer designing a game to a team of individuals with multi-million dollar budgets working for several years to produce a single game.

It seems as if every devoted gamer wants to be a game designer. Many think they can do it easily, because they know how to program or have a great idea for a game. But how do you go from having a great idea, to producing a great game?

Rules

The rules of a game depend on the game genre. These rules define what actions or moves a player can and cannot make; where they can and cannot go, and how they will win the game. Most of the games rules are not given to the player, or in the games instructions. They are inherent to the game and govern the playing process. For instance, in a puzzle game such as Tetris, the player can only move pieces where they will fit. If the shapes are not an exact match, the piece cannot be moved. The rules of a game also define the obstacles or challenges the player will face throughout the game (Bartle, 2003; Rollings & Adams, 2003).

Goals / Objectives

The goals and objective of a game establish how the game will be played and won. It defines the victory condition, or how the game will decide the winner.

Outcomes / Feedback / Consequences

The outcome of a game will be win, lose, draw or depending on the nature of the game, no outcome. A game should have one or more loss conditions, as well as the

victory condition. Some games, however, have no outcome – they are to be played purely for fun, or in competition with others, to get the highest score.

Challenge / Competition / Opposition / Conflict

Games can be competitive in different ways. Some games have clearly defined competition, one player wins and the other loses. Other games are played in competition to achieve the highest score. The competition can be with another player, non-player or the player themselves.

Interaction / Interactivity

Interactivity is how the player interacts or acts within the game world. The way the player jumps, shoots or dunks, how they interact with their competition or enemies, what motions and actions they can make. The way a player operates in the game world is called the games interaction model.

There are two prevalent interaction models, avatar and omnipresent. In the avatar interaction model, the player plays on one screen or level until he/she completes the objective, or loses. In the omnipresent model, the player can enter and exit different screens or levels at will. Perspective is also a facet of interactivity. It defines how the player views the game world. Perspective can be third person, through the eyes of another, first person, through the player's eyes, or side scrolling (Rollings & Adams, 2003).

Story

To create a great game, the game itself must be fun to play and give the player a reason to play. This reason to play is called the story. The story can be as simple as instructions for the player e.g. save the princess or it can be long, drawn out and convoluted.

The story is inherent to the game; it describes why the players are there, what the goal is, and what obstacles they will face along the way. Computer games create fantasy, and allow the player to become immersed in the game. Some stories are abstract and the player is told more about the story as the game unfolds. The game play is actively involved in the story. Other stories have nothing to do with the game play, but simply make the game more interesting (Rollings & Adams 2003). Figure 2 captures all the elements cited above necessary for good game design.

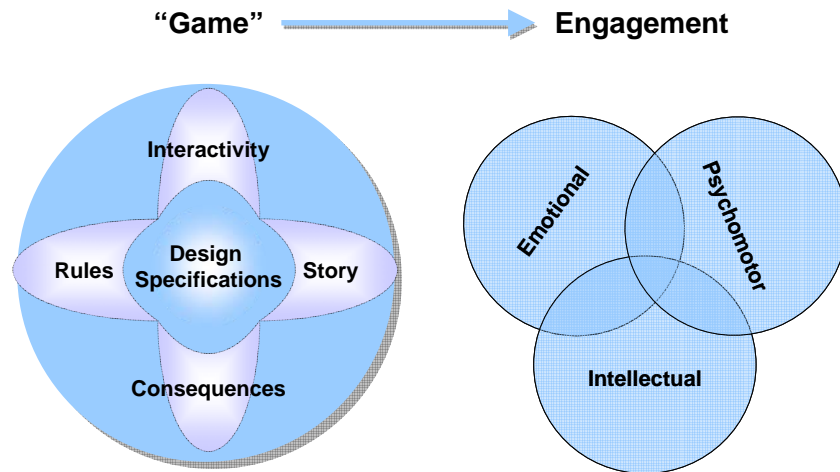


Figure 2: Gaming Model Adapted from Chris Clark's Principles of Game-Based Learning

Video Game Capabilities

2-D

Games can be 2-D or 3D. A dimension is essentially a degree of freedom or movement the player is allowed to make. In 2D games, the player can only move right to left and up and down. The older arcade games with flat shapes moving in a plane were all two-dimensional. Asteroids was the first game with two-dimensional player motion. While some games continue to be 2D, the trend is to offer them in 3D (Morrison, 2002).

3-D

3D games have the same movement as 2D games but offer forward and backward movement as well. Omerick (2004) teaches that “the form of a three-dimensional object can be either revealed or hidden depending on how the light hits the object and at what angle with respect to the camera” (p158). Newer console and computer games where the player moves about in a virtual reality are three-dimensional. Popular examples of this are the Maxis games SimCity and The Sims.

Immersive worlds

Immersive worlds are worlds that are so engaging and realistic that the player becomes “immersed” in the world, forgetting that the world is a fantasy. They are virtual

worlds, and are also known as persistent worlds. This type of game can be single or multi player and the environment can be controlled by the player. In multi player mode, the players interact with one another as well as the environment. Bartle (2003) states “because the environment continues to exist and develop internally (at least to some degree) even when there are no people interacting with it; this means it is persistent” (p1).

Massively Multiplayer Online Games (MMOGs)

Massively Multiplayer Online Games are games that allow at least 128 players to interact with each other in the game world. These persistent or virtual world games usually charge a fee to join. MMOGs have grown in popularity over the years, though the industry is currently in a wait and see state. However, Mulligan and Patrovsky (2003) believe that “most current game manufacturers, however, are planning to enter the MMOG market, with the exception of Nintendo” (p7).

MMOG’s actually date back to the late 1960’s, but experienced a large growth during the 1990’s. MMOG’s are defined by a set of rules so that the realm of possibilities is known by the players. There are 3 types of MMOGS - classic games such as chess or scrabble, hybrid games that can be used at home or with an internet connection, and persistent or immersive worlds (Mulligan & Patrovsky 2003).

Video Game Form and Aesthetics

The functionality of the user interface is the most important consideration and the user interface should fit the game. In adventure games, aesthetics is more important to support the notion of a fantasy world, but in a puzzle game, for instance, aesthetics is not as important.

However, for most games, the colors used in video game graphics should be carefully chosen to support the game play and storyline. For example, Omerick (2004) tells us the “red means hot and dangerous; blue means cool and safe. There is no doubt that these colors can evoke those particular emotions and feelings if presented properly, but it is important to remember that you as an artist can evoke any emotion you want with any color” (p158). The bottom line? The environment should support game play and complement game play, not detract from it (Meigs, 2003; Omerick, 2004).

CONCLUSION

Video games utilizing modern computer and artificial intelligence technology offer the potential to waste countless hours in meaningless, isolated activity. They also offer some of the most intriguing possibilities for individualized learning since the invention of writing. The challenge is to find ways to harness the entertainment power of this technology along with its ability to change in response to input from a user in such a way that useful educational goals can be accomplished. Developers of video game-based learning can benefit from advances in learning theory to help direct instructional content and measure the effectiveness of their products. This paper will attempt to provide an overview of some of the principle areas of knowledge, with special emphasis on adult learning theory, which can aid in the creation and evaluation of new, more sophisticated educational tools.

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