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THE UNIVERSITY OF ALBERTA

THE USE OF GAMES FOR TEACHING HIGH SCHOOL CHEMISTRY

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "The Use of Games for Teaching High School Chemistry" submitted by Harry P. Klann in partial fulfilment of the requirements for the degree of Master of Education.

M. A. Nay
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Date June 6 1980

To

Hertha, who helped make it possible;

Paul, Heidi, and Gerhardt,

who possibly made it.

ABSTRACT

The purpose of the study was threefold: to determine the mode and use of games for teaching high school chemistry; to develop an assessment instrument for the assessment of games for teaching chemistry; to develop a compendium of modes of use of games for teaching high school chemistry. A survey questionnaire was prepared and sent to a sample of chemistry teachers. Results indicated that chemistry teachers had had little experience with using games for teaching. Further, they indicated that teachers required practical information to enable them to make a decision about the use of games for teaching.

Gaming experts agreed that there was a need for a means of assessing games for teacher use. Criteria for such an assessment instrument came from respondents to the survey questionnaire, gaming experts and experts in curriculum materials evaluation. The instrument was modeled, in the main, after the proven format designed by the EPIE associates. The games assessment instrument had three main parts, namely: Part 1, dealing with the physical characteristics of the game; Part 2, dealing with the prerequisites required for the use of the game; Part 3, dealing with the internal consistency of the game.

Teachers responding to the survey questionnaire indicated that they required some ideas about how they could use games for teaching chemistry. The compendium of modes is a concise collection of ways in which games could be used; sources of information for this

compendium came from respondents to the survey questionnaire, game materials, and from gaming experts. The use of the assessment instrument and the ideas from the compendium should result in successful gaming in a chemistry classroom.

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To my children, Paul, Heidi, and Gerhardt goes special thanks for their understanding and encouragement: "Go and finish another chapter tonight, Daddy, so that we can have you back again."

To my wife, Hertha, goes my heartfelt thank you for her unfailing love and support throughout this venture.

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CHAPTER 1

THE PROBLEM

Background to the Problem

The teaching of science requires the active participation of students. Bruner (1966) called for "vicarious experiences" which model real life. He contends that unless students are able to put ideas to use and test their relevance, the ideas become meaningless. Among the suggestions for meaningful activities Bruner includes educational games. Many others (Abt and Cogger, 1969; Boocock, 1966; Coleman, 1966; Doran and Watson, 1973; Tansey and Unwin, 1968; Spencer, 1977) point out the value of using games to motivate, to test ideas and concepts, to develop higher cognitive skills, attitudes and procedures, and to help students to see the relevance of what they are learning. They see the use of educational games as one strategy to involve students in a meaningful way.

Much of the emphasis on the use of games for teaching has been in the social sciences (Abt and Cogger, 1969; Megarry, 1975; Twelker, 1972; Wentworth and Lewis, 1973). Yet the potential that games possess for learning ought not to be overlooked for science teaching (Bruner, 1966; Abt and Cogger, 1969; Ellington and Percival, 1977; Doran and Watson, 1973; Spencer, 1977). It is true that science games have been developed and published, but they are given little attention in the several game guides that have been published (Megarry,

1975). Because the development of science games is still in its infancy, the quality of the games available is variable (Fletcher, 1971 b; Twelker, 1972; Wentworth and Lewis, 1973; Spencer, 1977). Consequently the science teacher must have some way of evaluating games for their approach or mode of play, for their quality or content, and for their appropriateness in a particular classroom setting. It is highly important for the success of the game, in teaching and meeting objectives, that the teacher be thoroughly familiar with the game, its format, procedures and objectives as well as suitability to class needs (Gordon, 1970; Fletcher, 1971 B; Megarry, 1975; Tansey and Unwin, 1968; Twelker, 1972).

Statement of the Problem

The purpose of this study was to:

1. Determine the extent and mode of use of games by a selected sample of high school chemistry teachers.

2. Seek answers to the following questions:

(a) Is there a relationship between years of teaching experience and the use of games by chemistry teachers:

(b) Is there a relationship between years of post-secondary education and the use of games by chemistry teachers?

3. Develop an instrument for assessing the potential of games for instruction in chemistry.

4. Prepare a compendium of modes of using games for teaching chemistry.

Overall Design of the Study

The problem was approached as follows:

1. A questionnaire was sent to a selected sample of high school chemistry teachers (Appendix 1). The sample consisted of high school chemistry teachers from both the Edmonton Public and Separate School systems. The results of the questionnaire were compiled and used to determine the extent and mode of use of games by these teachers.

2. The questions posed in the statement of the problem were restated as null hypotheses and their significance was tested using the chi-square statistic.

3. Information from the questionnaire, as well as that from selected references, was used to develop an instrument for assessing the potential of particular games for classroom use (Appendix 2).

4. Information from the questionnaire, from selected references on the use of games in the classroom and from other teaching areas, like Social Studies, was used to compile the compendium of modes of using games for teaching high school chemistry.

Definitions

An educational game or simulation is an activity which imitates real circumstances and aims to teach or develop one or more of the following: content, skills, and attitudes. It may incorporate rules, a time span, and competition. Playing the game or gaming could involve such things as game boards, cards, or dice; it may involve people playing roles in a given setting; or it may be a combination of these.

The mode of using a game is the way in which it can be used to teach or develop knowledge, skills, or attitudes.

The compendium of modes is a concise collection of ways in which games could be used for teaching chemistry.

The assessment instrument provides informative, analytical and in part, judgmental components for assessing chemistry games. In the EPIE mode, the final decision about the acceptability of the game is left up to the user.

The Delimitations

1. The study was delimited to high school chemistry instruction. Since this was the researcher's teaching area, it was both of interest to him and also of practical value in his teaching.

2. The study was delimited by involving chemistry teachers from Edmonton high schools.

3. The study was delimited by not including laboratory exercises, even though they involve an "imitation" of the activities of scientists.

4. The study was delimited by not including computer simulations. Although innovative things have been done with such simulations, computers are generally not available for use in the high school classrooms.

5. The study was delimited by using selected chemistry games for illustration.

6. The study was delimited by using only face validity procedures for the assessment instrument.

7. The study was delimited by using verbal responses and reported use of games by teachers as partial sources of information for the development of the compendium.

Outline of the Thesis

The study is organized around seven chapters. In Chapter 1

the problem is introduced and in Chapter 2 the related literature is reviewed. The survey design is discussed in Chapter 3 and the results are presented in Chapter 4. The development of the assessment instrument is discussed in Chapter 5; the instrument itself is found in the appendices. In Chapter 6 the compendium of modes of using games for teaching chemistry is developed. The summary, conclusions and recommendations are found in Chapter 7. The appendices include such things as the assessment instrument, survey questionnaire and list of available games.

CHAPTER 2

THE RELATED LITERATURE

Introduction

The purpose of the review of the literature was to briefly trace the origins and evolution of educational games. As well, various experiments and investigations of an educational nature which relate to the use of games in the classroom and subsequent claims on their effectiveness are reviewed. However, it must be stated that most references in research and experimentation come from the area of the social sciences. Little research has been found that relates directly to the use of games in the science or chemistry classrooms. Consequently, inferences must be made from the results of the research in other subject areas which can be applied to the teaching of chemistry. Since the interest in science games is growing, it is expected that research on their use in the science classroom would grow as well (Spencer, 1977; Ellington and Percival, 1977).

A Historical Perspective

It is impossible to establish precisely the historical origin of games (Inbar and Stoll, 1972). However, some developments, within the framework of their historical contexts, are described in this section.

Games, athletic contests and other public spectacles were a salient feature of the social and religious life of ancient Greece and

Rome. The Greek games are said to have played an important role in the development of an appreciation for physical beauty, so typical of Greek art and literature. The Roman games became an important means for political leaders to gain favor with the people; games were no longer held primarily for their religious and social reasons, but were called when politicians believed that it was to their advantage to do so (Robb and Garrison, 1963).

Chess was developed some two thousand years ago as a representation of war and is said to be the oldest military game (Tansey and Unwin, 1968). From chess there developed more involved and strategically sophisticated war games as the need for prepared, knowledgeable military personnel arose; the battlefield was no place to learn strategies because one bad decision could prove to be fatal (Carlson, 1969).

The carnivals of the ancient and medieval world were also a kind of game and have been interpreted as 'institutionalized simulations.' People, whether young or old, rich or poor, master or slave, could exchange roles for the duration of the festivities. They could thus simulate the actions and life of someone outside of their own social class. This is said to have helped to reduce the tension between social levels or classes, for even the poorest of men had his day to be king (Inbar and Stoll, 1972).

In the middle ages knights learned how to handle their weapons and horses by preparing for and participating in tournaments, which were simulated fights. Hunting was also considered to be a means of preparing a potential soldier by helping him to become more familiar

with the terrain, to develop his horsemanship and to build endurance (Inbar and Stoll, 1972).

From medieval times on, the most noticeable developments were seen in the war games because Europe underwent military conflict decade after decade. As military strategies became more complex and sophisticated, so did the war games. Heretofore these games had been variations of chess; pieces were moved on a board in such a way as to simulate military maneuvers. This gave cadets, officers and generals a means of studying strategies without the reality of the battlefield being a necessity. However, the Napoleonic wars, involving massed armies and rapid maneuvers, demonstrated the need for more realistic war games. Consequently the Prussians, in 1824, developed a game which transferred the activities from a board to a map, thereby simulating actual military operations. By 1860 these games included all the elements of modern military operations: time, involvement of pertinent environmental factors and detailed simulated maneuvers and activities (Carlson, 1969). The Prussians continued to be the acknowledged leaders in this area and many of their innovations have become a basis for modern war games which have been adopted by the armed forces of countries throughout the world (Carlson, 1969; Tansey and Unwin, 1968).

Games in education are not "new" either. Philosophers of education, from Plato on, have indicated the value of simulated events in the form of drills and training exercises. For example, Rousseau, in his book L'Emile, proposed an education program which included games and artificially created situations (simulations) (Inbar and Stoll, 1972).

In North America, teachers in many of the one-roomed, multi-graded schools had to rely on drills and training exercises for teaching and learning. Who could forget one of the most popular games for years, the Spelling Bee.

Yet, it took many years, well into the twentieth century, for games to formally be included in school curricula. This is due to the prevailing belief, in the nineteenth and early twentieth centuries, that games were activities characterized as being "cultural residual or luxury items" (Boocock, 1966). Spencer's (1873) surplus energy theory of games typifies the sociologist's view of games during that time; he contended that the "time and strength not wholly absorbed in providing for immediate needs" allowed for "unnecessary" activities, the playing of games (Boocock, 1966, p. 2). Thus, in an atmosphere where games were considered frivolous and separate from the serious matters of life, they were not formally considered as a credible teaching strategy.

Modern Developments

Military conflicts, wars, and rumors of wars continued on into the twentieth century. Consequently, war games were further developed and extensively used to train military personnel. These war games played an important role in both the First and Second World Wars. Fleet Admiral Chester Nimitz explained their importance when he said:

> The war with Japan had been re-enacted in the game rooms . . . by so many people in so many different ways that nothing that happened during the war was a surprise--absolutely nothing except the Kamikaze tactics toward the end of the war . . . (Carlson, 1969; 5).

Yet, in spite of their many benefits, the war games were not without their shortcomings. Carlson (1969) reports that, rather than

take the war games seriously, some Japanese planners viewed them as a way of imposing their will on dissident colleagues. Generals would overrule the decisions of the game umpires and impose their own decisions. Thus the games were used to argue predetermined convictions instead of being used to investigate possible enemy reaction to a planned exercise.

Roberta Wohlstetter (Carlson, 1969, p. 8) points out another shortcoming of war games, namely, the failure to correctly interpret enemy psychology, intentions and values. She comments:

> This inability to imagine enemy psychology and tactics is, of course, a flaw inherent in most war games; the strategies are as good as the players and, on the whole, are typical of the players rather than of their identities in the game.

In spite of these identified shortcomings, war games were successfully used and continued to be developed. The computer gave them considerable impetus. This allowed for greater variety and complexity of strategies. As well, computers provided instant feedback on the consequences of the decisions made by the participants. With the computer acting as judge, tinkering with the outcome became much more difficult.

Today war games are used extensively in the training and preparation of soldiers and officers in armies throughout the world. In 1976, Ross reported that a carefully planned, dramatic rescue of hostages held in Uganda was made possible by training Israeli troops through the use of a simulation of the actual operation. And in 1977 a similar rescue was carried out by German commandos at Mogadishu ("Triumph at Mogadishu," 1978). The success of war games is summarized by Ricciardi:

> In the war games conducted by the Armed Forces, command officers of the Army, Navy, and Air Force have an opportunity to practice

> decision-making creatively in a myriad of hypothetical yet true-to-life competitive situations. Moreover, they are forced to make decisions in areas outside their own specialty; a naval communications officer, for example, may play the role of a task force commander. (Inbar and Stoll, 1972, p. 39)

In the years following World War II, the expanding economies of the countries of the Western World led to a period of rapid growth in business and industry; as a result, the need for more managerial staff developed. The traditional methods of training (lecture, seminar and 'on-the-spot training') were too slow and lacked, in the case of the former methods, contact with reality. The success of the war games led the American Management Association to seriously consider answers to the question:

> Why not a business "war game" in which teams of executives would make basic decisions of the kind that face every top management--and would see the results immediately? (Inbar and Stoll, 1972, p. 39)

As a result they developed what is probably the first business game suitable for training management personnel, called Top Management Decision Simulation (Tansey and Unwin, 1968; Inbar and Stoll, 1972). The use of the computer provided similar advantages to its use in the war games, namely the ability to increase the number and complexity of variables and instant feedback. However, the Association reported that companies viewed games as a panacea for their managerial problems. "Our development triggered a fad in which games were a flossy new product around which some companies tried to build entire training programs." (Carlson, 1969, p. 9) This complete dependence on games for training was soon met with disillusionment; games alone could not "do it all." Company officials soon learned that games would not solve all management training problems. Like the armed forces, they

incorporated games into their training programs and learned to use them to best advantage. For example:

> At Proctor and Gamble Co. . . . employees several times each year are asked to break up into teams of four and spend six hours playing VENTURE, a company game. New sales personnel, management trainees and clerks and production workers who have been with Proctor and Gamble for at least five years play in each of the company's 14 plants and its Cincinnati home office. The game puts company employees in the shoes of a simulated management team running a firm that makes cake mix or detergents. It gives them the opportunity to see the total decision-making process involved in running a business . . . VENTURE gives hourly workers a new appreciation for management problems along with the realization that their own jobs are important to the company's operations. (Carlson, 1969, p. 10)

However, it was not until recent years that games became formally related to education. ". . . education has taken from business a method which business in its turn had borrowed from military training." (Tansey and Unwin, 1968, p. 1) The first recognized use was in the training of school administrators, much in the same way that business chose to train managerial personnel; in these games the prospective school administrator met and dealt with problems similar to those to be faced in his career. This method was subsequently also used in teacher training (Abt, 1966; Cruikshank, 1966).

Finally, games made their way into the schools. James S. Coleman of the John Hopkins University was one of the pioneers in the game technique for the classroom. From the beginnings of the John Hopkins' Project in 1962, the development of games for elementary and secondary schools had mushroomed; these games were mainly in the social sciences and were of the role-play type. Zuckerman and Horn (1970) reported that in the ten year period of 1942-1952 less than ten games were published; however, in the first four months of 1970 there were over

sixty games published. Research into their effectiveness as a teaching strategy had also begun. Boocock (1966) contends that this was a sign that educational gaming was coming of age.

A Basis for Educational Games

At the beginning of the twentieth century games were generally considered to be unrelated to necessary, serious day-to-day activities. However, Boocock (1966) reports that people like Simmel, Gross and Mead caused a change in the way games were viewed. They contended that the games people played most frequently were the ones that mirrored real life. In this way a person can participate in a "real life like" activity without having to contend with the consequences of his actions; thus the player can focus his attention on the game, play it seriously, experience the results of his actions without 'suffering' the consequences. Further, play is a serious business and exists for the purpose of practice or exercise; often the games played are prototypes of later adult behavior. In fact, so necessary is play to development that a period of the life cycle, childhood, has been set aside for it. Games are also necessary for a child to develop his social "self." In a game he soon learns what is expected of him and what he expects of others.

Lehman and Witty have related the kinds of games children play to the stages of their mental and physical development (Boocock, 1966). Piaget (1948) has further developed this concept. He identifies four developmental stages: sensori-motor (first 18 months of life), pre-operational (up to 7 years), concrete operational (about age 7 to about age 11 years), and formal operational (beginning at about 11 or 12 years of age). Piaget theorizes that children advance through sequences of

concept development; this advancement is governed by: (a) maturation, (b) experience, (c) social transmission, and (d) equilibrium. Through interview and observation he describes how the kinds of games or the way in which they are played, in each stage of development, are similar to the child's outlook of the world at that stage. The child goes from manipulation and non-social games and play, in the sensori-motor and preoperational stages, to the high interest in rules and their function in guiding the actions of the players, in the concrete operational stage. For children, games are more than a simulation of life; they are an introduction to life itself, with its rules, roles and expectations (Phillips, 1976).

Thus by the middle of the twentieth century, games were viewed as important to the development of children and integrated with the serious activities of life and "growing up."

Educators have long stressed the importance of methodology and relevance in teaching. Durkheim (1956), at the turn of the century, theorized that the objectives of education were social. Therefore the ways in which students were taught and rewarded ought to have been essentially related to later adult life.

Dewey (1916, p. 46) condemned the teaching approach which he described as "teaching by pouring in and learning by passive absorption." In these situations, he charged, teachers assumed the most active roles in teaching the students and students took little or no responsibility for what they learned. Dewey stressed the need for activities that would enable the child to build a link with his environment; these activities should ". . . reproduce the conditions of real life

(Dewey, 1915, p. 292). He further pointed out that those things which people tended to learn best were those which were essential for effective interaction to provide the students with "real life" experiences in the classroom, as well as means to test their relevance and importance to the student's life.

Bruner pointed out that failure to capture a student's interest in his school work created a break in the learning process.

> Students should know what it feels like to be completely absorbed in a problem. They seldom experience this feeling in school. Given enough absorption in class, some students may be able to carry over the feeling to work done on their own. (Bruner, 1960, p. 50)

He suggested that "vicarious experiences" are a means of reproducing "real life" situations, as well as providing a way for students to become absorbed in their work. Participation played an important role in the vicarious experiences that Bruner advocated. A way of stimulating participation was

> . . . by the use of games that incorporate the formal properties of the phenomena for which the game is an analogue. In this sense, a game is like a mathematical model--an artificial but often powerful representation of reality. (Bruner, 1966, pp. 92-93)

Bruner asserted that the "devices" necessary for providing vicarious experiences, such as films, sound recordings and games, should not fall into the category of "enrichment," but rather they should become basic educational tools (Bruner, 1960, 1966).

Coleman (1966), a sociologist, bases his criticism of North American secondary schools on the results of a number of studies he conducted. He argues that the secondary schools of today are still guided by the principles of nineteenth century needs and have failed to include the problems of the late twentieth century. He identifies

three main defects of the secondary schools.

The first defect is that schools teach for some future goal. The skills students learn are the ones which they will need for some future "real life activity." Since the relevance of these skills is not immediately apparent, there is little motivation to learn them well. The second defect centers on the forced, involuntary nature of the curriculum. Students are given little motivation to pursue studies to the limits of their abilities; education is reduced to a state of completing assignments. The third defect is the dual role played by the teacher as both judge and teacher. Since the teacher must provide for a learning atmosphere and at the same time give grades that will in some way affect the students' futures, there often develop negative student attitudes which interfere with learning (Coleman and Boocock, 1966).

Gordon adds her support to Coleman's critique of education.

> The fundamental deficiency of the school system is its failure to motivate the youth of the country to want to learn. . . . This is probably due as much to the methodology used as it is to the fact that what the schools teach is perceived to have little connection with the real world. (Gordon, 1970)

Coleman and Boocock (1966) contend that games, though not a cure-all for these defects, go a long way in meeting these problems and providing solutions. Firstly, games bring the future into the present. In a game, the student must apply his skills, play roles and make decisions <u>now</u>. He sees the results of his actions and the relevance of the skills he has learned without having to wait for some future "real life activity." Secondly, the games and their play motivate the student to want to participate and to use his skills; he

will identify skills that he has not adequately mastered and those that he still needs to learn. Thirdly, games are self-judging; the outcome of the game decides who has "won" and what the results of the individual player's actions were. This relieves the teacher, at least in part, from the role of judge and allows him more freedom to act as helper and consultant to the student.

Tansey and Unwin (1968, p. 6) argue that, as an alternative teaching method, the use of games in the classroom is justified. ". . . do not good teachers cast about for alternative ways of presentation? Gaming is justified on this basis alone. . ."

Because these arguments apply to teaching in general, specific application could also be made to the teaching of science and, in particular, to high school chemistry. Indeed, the interest in using games for teaching science seems to be growing since more games have been published recently (Spencer, 1977; Ellington and Percival, 1977).

Initially most of the games were concentrated in the social science area. This is probably due to the fact that Coleman and his associates working on the Johns Hopkins' Project were sociologists (Zuckerman and Horn, 1970). Further, the science curricula of the post-Sputnik era, like the Chemical Education Material Study's (Chem Study) chemistry course, were very subject-matter oriented. Experimentation and process skills, the activities which scientists use in pursuing their profession, were of prime importance (Nay and Associates, 1971; Sabar, 1979).

However, world problems emerging on a large scale in the early seventies, such as energy shortages and pollution, changed the public

mind towards science. The Time (1977, p. 48) essay sums up the public attitude that was developing.

> . . . there was only one way, by the law of psychological gravity, for Sci-Tech's prestige to go. Sure enough, down it went. And in its place has risen a new public attitude that seems the antithesis of the former awe. That awe has given way to a new skepticism, the adulation to heckling. To the bewilderment of much of the scientific community, its past triumphs have been downgraded, and popular excitement over new achievements, like snapshots from Mars, seems to wane with the closing words of the evening news. Sci-Tech's promises for the future, far from being welcomed as harbingers of utopia, now seem too often to be threats.

This public opinion about science technology had its effect on science curricula. Blumenfeld (1976, p. 17) pointed to the need to "produce a scientifically-informed citizenry, one capable of making decisions in a world beset by technological and social problems." To this end, the National Science Teachers Association adopted a position statement.

> All teachers, and especially science teachers, are challenged to educate young people to expect, to promote, and to direct societal change. Awareness of the social aspects of science includes--
>
> Perception of the cultural conditions within which science thrives.
>
> Recognition of the need to view the scientific enterprise within broad perspectives of culture . . . society, and history.
>
> Expectation that social and economic innovations may be necessary to improve man's condition. (Blumenfeld, 1976, p. 17)

Sabar (1979, p. 263, p. 266) reports that the response from curriculum developers has been to produce materials with a different emphasis. "Rather than being organized purely on the basis of the science 'discipline, topics now arise from the relation of science to important issues in society.' . . . We can see that science for scientists only is not the attitude anymore."

This trend is also reflected in the general science and chemistry objectives for the Province of Alberta (Appendix 3).

Units for the chemistry courses, like "Environmental Problems" reflect topics which relate chemistry to society (Appendix 4). There is also provision for the teacher to develop a unit which might take into consideration local resources, characteristics and needs. The situation, as Sabar (1979) sees it, is to retain the basic essence of science and its processes, while answering the need to demonstrate the relation between science and society. It is his opinion that both these needs are being met by curriculum planners.

If these aspects of science teaching are taken seriously, then the science teacher is faced with a formidable task and a different role; not only must he be a subject matter expert, but also able to show the relation of science to other disciplines and to societal needs, as well as being an example in attitude (Blumenfeld, 1976; Gardner, 1975; Sabar, 1979).

Games offer the chemistry teacher an approach to this problem. (Game References are cited in Appendix 5.) There are games which drill content, like Chem Rummy; the object of this game is to make correct formulas for compounds. There are games designed to develop process skills, like observation and hypothesis formulation and testing. The Hypothesis Machine is such a game. Players are required to make observations, then formulate hypotheses based on these observations and finally to test these hypotheses. There are games which deal with problems like pollution. The Planet Management Game is one example; the players become managers of the imaginary planet Clarion; they make decisions about how to improve living conditions and experience the result of these decisions.

Thus games can have a place in teaching chemistry. This is

especially true in Alberta where there are elective units which teachers plan themselves and which are flexible so that a teaching strategy, like gaming, can be included.

What is a Game?

The purpose of this section is to review the various definitions of the word "game," and to choose a definition for the term "educational game."

The term "game" has been widely used; it is common to hear such phrases as: the game of life, the game of love, the political game, the education game or the ball game. Games are obviously an integral part of life, but what really is this activity called 'a game?' Berne, (1964, p. 49), a psychologist, analysed people's interactions as a series of games and used this as a basis for his popular book Games People Play. It is from within this context that he defined the term: "A game is an ongoing series of complementary ulterior transactions progressing to a well defined, predictable outcome." However, this definition applies mainly to the interactions that Berne describes in his book and is thus too narrow in scope for defining the term "educational game."

Huizinga (Boocock, 1966, p. 1) offered a definition of broader scope:

> (A game is) . . . a voluntary activity or occupation executed within certain fixed limits of time and place, according to rules freely accepted but absolutely binding, having its aim in itself and accompanied by a feeling of tensions, joy and consciousness that it is different from ordinary life.

Suits (1967, p. 148) offered a related definition from a philosophical point of view:

> To play a game is to engage in activity directed toward bringing about a specific state of affairs, using only means permitted by specific rules, where the means permitted by the rules are more limited in scope than they would be in the absence of the rules, and where the sole reason for accepting such limitations is to make possible such activity.

Suits argues, like Huizinga, that rules are necessary, for they provide the means for playing the game and that the game has not really been played if the rules are not followed. Whereas the rules are necessary for the game, they are by no means mandatory for actions apart from the game. However, for the purpose of learning, educational games must include rules or directives which are related to "real life." For example, the game Chem Rummy (Appendix 5) involves a set of rules, as described by Suits, for manipulation of the cards. But there are also the rules of chemical bonding that must be used; these rules hold whether or not the game is being played.

Coleman (1967, p. 68) gives a broader definition:

> Games may be regarded as a special invention in which children or adults practice with the components of life itself, a kind of play within the larger play of life itself.

This definition includes the element of "real life" and draws strongly on this aspect. However, it fails to include some of the constraints or rules necessary for the game to function in a learning setting, apart from the consequences of "real life."

Gordon's (1970, p. 8) definition attempts to draw those aspects together. "A game may be defined as any simulated contest (play) among adversaries (players) operating under constraints (rules) for an objective (winning)." However, with terms such as "contest," "adversaries" and "winning," her definition leaves the impression that an educational game is somewhat akin to a spectacle in a Roman colliseum.

There are, however, two basic terms that educators use when referring to game activities, namely, games and simulations. These terms are often used interchangeably, although simulation sounds more serious and implies structure and formality. For this reason, some educators favor the term simulation; perhaps it has a better ring in the ears of the public (Gordon, 1970).

Tansey and Unwin (1968, p. 6) define a simulation as ". . . an analogue, a reproduction of the reality. . ." Twelker offers a similar broad definition, without any reference to teaching and learning. "(Simulation is) the obtaining the essence of something, but without all aspects of reality." (Zuckerman and Horn, 1970, p. 373) Wing (1968, p. 41) aims his definition at the use of simulation for teaching.

> . . . simulation may be defined as an imitation of real circumstances aimed at providing a learning environment; in other words, simulation is a technique by which the essential features of some object or process are abstracted and recombined in a model which represents the function of the original and can be manipulated for the purpose of study or instruction.

This definition includes the essence of the two above as well as the specific reference to learning.

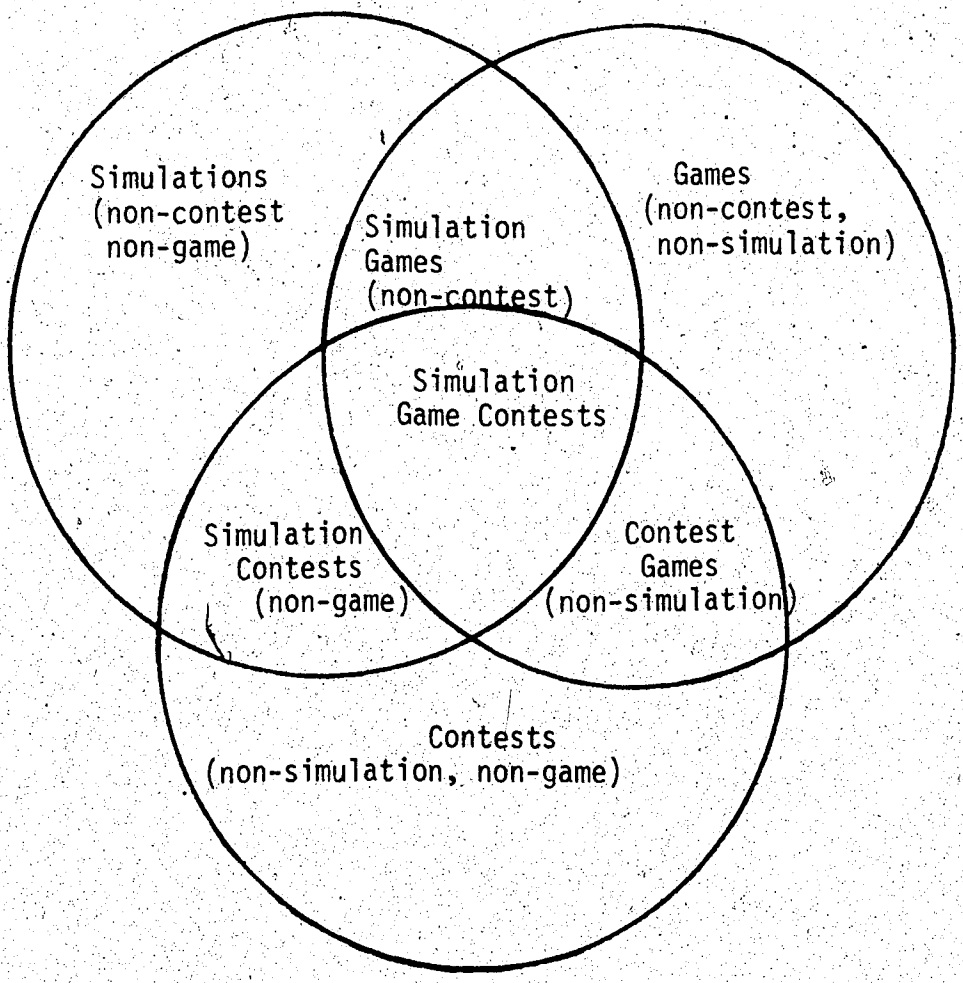
Gordon (1970, p. 12) contends that "all games are simulations; not all simulations are games." They are similar because they both reproduce some aspect of reality. They are different because games also include rules for playing the game, as well as competition and winning, whereas simulations are centered around the activities of the slice of reality they portray.

Tansey and Unwin (1968, p. 50) argue that

> . . . It is not particularly profitable to draw a line between simulation and academic gaming. Both academic or educational games and simulations portray some aspect of reality for the purpose of learning. Hence, there is little reason to insist on

separating these activities; they are both equally useful for learning and accomplish similar ends. The key difference between them is the degree of competition; games tend to have more "play" rules and more open competition.

Shirts (1975) further elaborates on the relation between games and simulations; he uses three key terms: simulations, games, contests. The following Venn diagram represents the relationship of these activities to each other.



This diagram results in seven categories. Shirts demonstrates what they entail by giving examples of each one.

Simulations: Mathematical formulas; models of physical systems, military-industrial systems, social systems, role-playing; film; literature; painting; sculpture.

Contests: Man vs. man; man vs. himself; man vs. nature; nature vs. nature; business competition; political contests.

Games: Encounter games; many of the non-simulation theater games; much of what is generally described as play.

Contest Games: Sports, gambling; mathematical games; word games. This is the most common definition of games.

Simulation Games: Playing store; playing house; ring-around-the-rosies.

Simulation Contest: An industrial engineer wishing to determine which of two warehousing methods was most efficient, simulates a contest between them to determine which one to adopt.

Simulation Game Contests: Most educational games fall into this category. They are contests because they are concerned with the allocation of scarce resources such as money, influence, time, space, etc. They are games because the participants agree to abide by a set of conditions or rules. They are simulations because they model reality.

Although Shirts indicates that most educational games fall into the latter category, this still does not allow for the inclusion of some of the drill type games, like Precipitate (Appendix 5). Perhaps it could be argued that the cards used in the game are the "scarce" resources that are allocated for use in its play; there are also a set of rules governing play, as well as those bonding rules of chemistry involved when compounds are formed. Even such a game could be

called a simulation game contest.

A definition is needed which incorporates the key aspects: modeling reality; rules; competition; role playing; use of hardware, like cards and dice; allocation of time; purpose. Below is a definition that includes these aspects:

> An educational game or simulation is an activity which imitates real circumstances and aims to teach or develop one or more of the following: content, skills, attitudes. It may incorporate rules, a time span, and competition. Playing the game or gaming could involve such things as game boards, cards or dice; it may involve people playing roles in a given setting; or it may be a combination of these.

The intent of this study was to look at the concept of gaming and its application to chemistry teaching, as well as to provide as much useful information for teachers as possible. Too narrow a definition of games would limit this approach. However, under the proposed definition come a variety of games, from the simple drill and board games to the more complex role playing simulation games. The use of these various games for teaching chemistry is dealt with in Chapter 6.

Research on Gaming

The purpose of this section is to report on research findings related to the key claims made by proponents of gaming. These are that: games are highly motivating; games can be used to teach content material as well as develop higher cognitive skills; games can be used to help to develop attitudes. A number of reviews of research on educational games and gaming form the basis for this section. (Cherryholmes, 1966; Fletcher, 1971; Wentworth and Lewis, 1973; Fennesey, 1975; Hunter and Clark, 1977; Coombs, 1978). Little research has been found which deals directly with the use of games for teaching

high school chemistry. Consequently, extrapolations were made from the results of the present body of research, predominently in the area of the social sciences, and applied to the teaching of chemistry.

One of the most consistent and strongest claims for the use of games for teaching has been for the motivational value. After reviewing six studies, Cherryholmes (1966) could only conclude that the participants in the gaming process enjoyed these activities more than conventional classroom exercises; all of these studies dealt with the use of games for teaching social studies and related courses. (It should be further noted that these six studies were the only ones of any consequence available at that time.) Wentworth and Lewis (1973) concluded that games can have some influence in helping students become more actively involved in the classroom. They too reviewed research in social studies, but now had over forty research reports to study. Hunter and Clark (1977) reported that up to 1972, research reports were only able to cite general support for improvement in motivation. Later reports refer to conflicting findings. The basic problem seemed to be that motivation and its relationship to gaming was not clearly defined; was the reported increased motivation directed towards the learning of the subject matter or the playing of the game? Earlier reports were not specific; later reports indicated that researchers attempted to narrow down the motivational aspects to specific areas, with conflicting results. Researchers were no longer content to ask if students enjoyed the game; they now felt it necessary to ask if the motivation carried beyond the game to class work and, where applicable, to the real life which the game was said to simulate. Clearly,

researchers were now asking different kinds of questions and consequently their results should not be compared to those of the earlier studies. That games motivated students to participate in the gaming, was suggested by the earlier studies; however, that this motivation carried on beyond the play of the game, had not been established as a result of the later studies.

Another claim has been that games can be used to teach content material. All the reviewers, from Cherryholmes (1966) to Coombs (1978), agreed that research findings in this area have shown no significant difference between gaming and "conventional" instruction. However, Hunter and Clark (1977) reported that when a game was specifically designed to teach content, then it showed significant increases over "conventional" instruction. (It is important to note that many games are not designed primarily for learning content; thus, comparing them to "conventional" teaching, on this basis only, is not appropriate. Yet in spite of this type of comparison, games have still come out not better or [redacted] "conventional" teaching.) It has also been claimed that games [redacted] used to develop higher cognitive skills. Again, all the reviewers [redacted] the research reports agree that there has been no significant difference in the results of the use of games compared to the "conventional" teaching methods.

The studies done on educational games and their impact in the area of affective learning can be divided into several categories. First, the attitudes of students towards the use of games as classroom activities. All the reviewers pointed to positive students' attitudes towards gaming as a classroom activity. Second, changes in attitudes

towards the given course. Again, reviewers report that the research points to a positive attitude towards the course being taken, as a result of gaming. Third, other studies attempted to measure attitude changes towards the particular topic being studied through a game, like poverty. Again, the reviewers reported that students exhibited "positive" attitudinal changes towards the subject of study, when compared to the results of "conventional" study of the topic. The reviewers were generally agreed that the most positive results have been shown in the area of affective development.

Fletcher (1971) voiced a number of criticisms of the research that he reviewed; these were generally reiterated by Wentworth and Lewis (1973), Hunter and Clark (1976) and Coombs (1977). They felt that the research done on gaming suffered from many of the shortcomings that plague educational research. Many of the research projects were of the direct comparison of two methods, "one-shot" kind of research. Little follow-up or in-depth study has been reported on any one problem or topic. Few studies have been replicated in order to further substantiate results. Further, some studies had research design limitations which included population selection, test construction and validation, inadequate controls and limited statistical analysis of results. In general, these reviewers called for more information based on research of a better quality. Further, more research needs to be done in the area of the use of games for science teaching, and more specifically, chemistry teaching; there is little research reported in this area (Spencer, 1977).

What conclusions can be drawn from the results of the research and applied to the teaching of chemistry? First, that games seem to

motivate students to participate in class, but that there is no statistical confirmation that this motivation carries on beyond the play of the game. Games could be a way of fostering an enthusiastic, participating classroom atmosphere, which is in itself desirable. Second, games have shown no particular advantage for teaching content and developing higher cognitive skills; yet it has been shown that they can be used for these purposes and does not rule them out as a teaching strategy available to teachers of chemistry. Third, gaming has resulted in "positive" attitude development towards gaming activities, towards the courses in which the gaming was used, and towards particular topics that games have addressed. Since attitude development is an important aspect of chemistry instruction, games could well serve to assist in this way. All in all, gaming offers the chemistry teachers another approach to the daily routine.

Chapter Summary

Games have been a recognized part of civilization. Most prominent have been the war games used for centuries and highly developed and extensively used in the twentieth century. In spite of their successful use by the military, games in general were not taken seriously till the mid-twentieth century. Educational games did not become popular till the late 1960's and early 1970's and were first used in the social sciences. Research on the use of games had also begun and is considered by some to still be in its infancy. Compared to the war games, used and developed over the centuries, educational games have come a long way in a short time. Some critics of North American education have cited the educational game as a cure for the educational

shortcomings which they had identified. Results of the research do not support the claims that games can do it all; but they can be used as part of a total teaching plan, as Wentworth and Lewis (1973, p. 432) sum it up:

> . . . our discussion is not a ringing endorsement of educational games and simulations as the only answer to all teaching problems. . . . Although the exercises (games) . . . are an extremely useful and interesting part of a teaching-learning experience, they are not effective without other curriculum support--i.e., other materials, other activities, other media, and a well-prepared teacher. Preliminary evaluations from teachers-users indicate that the best exercises provide the most effective teaching-learning experiences when used as part of a total curriculum plan.

Whereas games were enthusiastically received by the social scientists, they did not become as popular with the science educators. However, with the trend away from the highly subject matter oriented science courses, to those speaking to the relationship of science to society and the inclusion of moral and ethical considerations, the door has been opened to a teaching strategy used successfully in the social sciences. (This trend is reflected in the present Alberta chemistry curriculum; the core and option units give the teacher more flexibility for the inclusion of gaming activities.) Some science educators believe that gaming is now becoming more widely accepted by science teachers. But if games are to be successful, teachers must be aware of how best to use them. It is the intention of this study to provide information for teachers. In Chapter 5, the assessment instrument, to assist teachers in selecting games for their use, is discussed. In Chapter 6, the collection of ways of using games for teaching chemistry, the compendium, is presented. It is hoped that, with the aid of this information, teachers will experience more success in

gaming. Along with more success should come more gaming. It is further hoped that, along with more gaming will come the added confidence needed to further encourage research on the use of games for teaching chemistry.

CHAPTER 3

RESEARCH DESIGN

The purpose of this study was threefold: to determine the extent and mode of use of games by high school chemistry teachers; to develop an instrument to be used by chemistry teachers for assessing games for classroom use; to prepare a compendium of modes of use of games for teaching chemistry. In this chapter the procedures for dealing with the first of these aspects of the study are presented. The remaining two will be dealt with in subsequent chapters.

The Survey Sample

In order to determine the extent and mode of use of games in teaching high school chemistry, a survey was planned. The sample consisted of high school chemistry teachers of both the Edmonton Public and Edmonton Separate systems. There are several reasons for selecting high school chemistry teachers. First, the researcher's interest and former teaching responsibilities have been in this area. Second, the Alberta high school chemistry curriculum now allows for flexibility since there are core units, elective units and provisions for locally made units. Games could be incorporated as a teaching strategy. Third, as reported in Chapter 2, games have been successfully used by the military, by business and by educators, particularly in high school social studies. Surely this teaching approach could also be used in high school chemistry instruction.

Due to the constraints of time and finances, the sample was limited to the two Edmonton School systems. However, teachers in large centers like Edmonton usually have more resources readily available to them. As well, there are more opportunities to interact with colleagues and resource personnel. As a result, the sample would be more representative of Alberta high school chemistry teachers from large, urban centers than of high school chemistry teachers in Alberta as a whole.

Both the Edmonton Public and the Edmonton Separate School Boards agreed to allow the researcher to survey the high school chemistry teachers under their jurisdiction. However, the decision to participate in the survey was left up to each individual principal and was made at the school level. One school agreed to participate in piloting the questionnaire. The remaining seventeen schools agreed to participate in the actual survey. All together seventy-six questionnaires were sent out. However, one school, with eleven teachers to be surveyed, subsequently decided to withdraw. The teachers there were already involved in a study and did not want to participate in another one. Further details about the return of the questionnaire are found in Chapter 4.

The Questionnaire

An initial draft of the survey questionnaire was prepared and three graduate students in science education at the University of Alberta, as well as the researcher's advisor, were asked to react to this draft. A subsequent draft was then piloted at one of the high schools, with seven chemistry teachers participating. A final draft

was then prepared (Appendix 1). The questionnaire was printed on goldenrod colored paper for easy identification by participants.

The final draft of the questionnaire consisted of two parts (Appendix 1). The main purpose of Part 1 was to gather professional data on the teachers and their schools so that the sample could be adequately described.

The purpose of Part 2 was to gather information about the teachers' contact with and use of educational games. The first three questions dealt with the degree of use of games and the circumstances prevailing at their respective schools. Question 4 dealt with information that teachers might need to help them decide whether or not to use games. Questions 5 and 6 dealt with information about the purpose for using games and the criteria used for selecting a game. Questions 7 and 8 dealt with the ways in which teachers would use games in the classroom. Questions 9 and 10 dealt with the advantages and disadvantages of using games as seen by the teachers of the sample. Question 11 gave the teachers an opportunity to list the titles of any games that they may have used. Finally, all participants were given the opportunity to request the results of the questionnaire; a space for their names and mailing addresses was provided.

The format of Part 2 consisted of a question, a number of statements that could be checked off and a blank space for adding any further responses and comments. It was found in the pilot phase that open-ended questions were often left blank. Therefore the final draft provided for the quick selection of responses as well as space for additional comments.

Validity and Reliability of the Questionnaire

Whenever data are gathered by means of a questionnaire, their worth is considered in the light of two key questions:

1. Does the questionnaire measure what it is supposed to measure?

2. Can the researcher be sure that responses have been honest and accurate?

The first question deals with Content Validity. Face and sampling validity are the two main components of content validity. Face validity is a measure of what the instrument appears to be measuring; this is usually evaluated in a subjective manner, like the use of a panel of judges. For this survey, the questionnaire was submitted to a group of three secondary education graduate students who were chemistry teachers, and the researcher's advisor, for scrutiny. This group acted as a panel of judges to determine the face validity of the questionnaire; they concluded that the questionnaire had such validity. Sampling validity is concerned with the adequacy of coverage of the "universe of behavior" being measured. The universe of behavior in this instance was the use of games by teachers and the circumstances under which they were used. As well, the possible use of games by teachers and circumstances under which this might be possible are necessary components for developing the assessment instrument and compendium of modes. Questions geared specifically to these areas have been included; also there are opportunities for respondents to write in comments and further replies, should this be necessary to fill in any missing gaps.

The second question addresses itself to a human behavior problem. Is the respondent in any way, either wilfully or otherwise, colouring his answer? There are several common causes for such distortion in the answers to questionnaires:

1. The desire to appear socially acceptable.

2. The desire to achieve maximum advantage in an evaluation situation. The motivations for both are similar, as are the methods to combat them. Therefore these two distortions will be treated together.

The only way to be absolutely certain that these distortions are not occurring is to make independent checks on the accuracy of the answers given. This could be done in one or more of the following ways: observing the respondents to see if their actions match their responses; asking colleagues to verify the respondent's responses; checking any documentary evidence for the confirmation of the respondent's replies. These methods were generally not available to the researcher: in the first and third instances, due to constraints of time and in the second instance, due to ethical considerations as well. Since this is not a teacher evaluation, there is little chance that the second cause for distortion of responses is significant. However, it is possible that the first cause for distortion could have an effect on how a respondent answers questions which might show him to be different from his peers. For example, in answering Question 1 of Part 2, a respondent might be tempted to mark that he had used games once or twice, even though, in fact, he hadn't used them at all; this could stem from a desire of the respondent to show others that he is indeed keeping up with new or different ideas. However, this too is expected

to be of a minor concern in this survey. There is nothing to be gained from such responses because respondents were assured that replies would be kept confidential.

3. Variation in conditions under which the questionnaire was answered also causes distortion of the replies. Such things as when the questionnaire was answered, how rushed for time the respondent was and what his frame of mind was when he answered, are factors causing variation in reply. These factors are considered important especially for attitude inventories where a respondent's attitude could indeed be different under different circumstances. Short questionnaires help to alleviate such problems. However, this is not considered to be a major factor in this survey since attitudes are not being measured and the questionnaire has been kept relatively short.

4. Distortion due to the format of the questionnaire. A common concern of this type is response set where a respondent answers consistently in one category regardless of the question; this usually occurs as a result of boredom. The present survey was kept relatively short to reduce this possibility.

In light of the above discussion it can be seen that the survey questionnaire used in this study had been designed to keep the usual problems associated with validity and reliability to a minimum. A possible shortcoming lay in the fact that it was not designed to enable the researcher to readily calculate a reliability coefficient like the Cronbach coefficient. However, since it was not the intention of this study to make statistical inferences based on the information of the questionnaire, this should not be of major concern.

Administration of the Questionnaire

After the school boards gave their permission to conduct the survey, the principals of the high schools were contacted. It was agreed that the final decision to participate in the survey should be made at the science department level. Department heads were subsequently contacted and in all cases, with the exception of one school as reported earlier, the teachers agreed to participate. The questionnaires were then mailed to the department heads, who distributed them to the chemistry teachers. The mailing also included a covering letter for each teacher, explaining the purpose of the survey and giving directions for the return of the completed questionnaires (Appendix 1). The department heads also collected the completed questionnaires on a pre-arranged date. Within one week, the questionnaires were picked up from the schools by the researcher. This provided the opportunity to meet many of the department heads and teachers and to thank them personally for their participation. Further details about the results of the questionnaire are reported in Chapter 4.

Analysis of the Questionnaire

The results of Part 1 were used mainly for describing the sample of chemistry teachers who responded to the questionnaire. The results of Part 2 indicated the extent and mode of use of games in chemistry teaching by the sample of teachers in terms of frequency counts of options given in the questionnaire. Table format was used to summarize the written comments and responses to each question.

There were two respondent characteristics which would have some bearing on whether or not games were used for teaching, namely, years

of teaching experience and years of post-secondary education. Two questions were posed:

1. Does the number of years of teaching experience influence whether or not a teacher uses games for teaching?

This question could be restated in the form of a null hypothesis:

Hypothesis 1: There is no relationship between years of teaching experience and the use of games for teaching.

2. Does the number of years of post-secondary education influence whether or not a teacher used games for teaching?

Hypothesis 2: There is no relationship between the number of years of post-secondary education and the use of games for teaching.

Both of these hypotheses were tested using the chi-square statistic. The test was based on the frequency of responses to the questions which identified the years of experience and years of post-secondary education as related to the reported use of games by these respondents. In order to satisfy the requirement of the chi-square test that the minimum frequency in any one cell be five, the respondents were divided into two groups: those that had not used games at all and those who had used games one or more times. The results of this test are reported in Chapter 4.

Chapter Summary

This chapter dealt with the design of the survey of the use of games by chemistry teachers. Specifically are indicated the nature of the sample, the content and structure of the questionnaire, its validity, stated questions and testable hypotheses, and the analysis used. Results of the survey are reported in Chapter 4.

CHAPTER 4

RESULTS OF THE SURVEY

This chapter reports the data collected during the survey, their analysis, the results of testing the hypothesis, and other findings.

The Sample Description

Altogether seventy-six questionnaires were sent to all the high school chemistry teachers of the Edmonton Public and Edmonton Separate School Boards. One school withdrew from the survey, as reported in Chapter 3. Hence sixty-five questionnaires were returned for an 86 percent response; however, three were returned with few responses and were not considered useable. This left a total of sixty-two respondents, for an 82 percent useable response.

Table 1 describes the sample of teachers used in the survey. On the average, the teachers had 5.1 years of university education, 9.8 years of teaching experience and 7.2 years of teaching chemistry experience. The sample was predominantly male. There were, on the average, five teachers at each high school involved in teaching one or more chemistry courses. Details of the teaching responsibilities of the teachers are given in Table 2. Only 26 percent of the sample of sixty-two respondents taught only chemistry courses. The respondents came from large schools where there were several teachers teaching chemistry; hence interaction with peers was possible. They generally

TABLE 1

YEARS OF TEACHING EXPERIENCE AND UNIVERSITY EDUCATION FEMALE AND MALE TEACHERS IN THE SAMPLE

	Female Teachers (8, 13% of S)		Male Teachers (54, 87% of S)	
	Range (yrs).	Means (yrs.)	Range (yrs.)	Mean (yrs.)
University Education	4 to 8	4.8	3 to 10	5.3
Teaching Experience	2 to 26	7.9	2 to 40	11.6
Chemistry Teaching Experience	2 to 18	5.6	1 to 35	8.7

TABLE 2

DISTRIBUTION OF THE TEACHING LOADS OF THE RESPONDENTS

Classes Taught	Number of Teachers	Percentage of Sample (62)
Chemistry only	16	25.8
Chemistry and Biology	12	19.4
Chemistry and Physics	9	14.6
Chemistry and Science 11	7	11.3
Chemistry, Biology and Science 11	6	9.7
Chemistry, Physics and Science 11	3	4.8
Chemistry plus some other combination of courses	9	14.6
TOTALS	62	100

had a lot of experience teaching chemistry, and had more than the usual four years of post-secondary education required for a Bachelor of Education degree. This meant that they should have had the opportunity to become confident in their teaching and familiar with trends in science education, as well as new ideas such as the use of games for teaching.

Table 3 describes the teachers' attitudes towards new ideas. Altogether, 86 percent of the respondents indicated that they were open to new ideas but only 26 percent of the sample said that they would readily try them. This is further discussed later in the chapter where the results of Part 2 of the questionnaire are presented.

TABLE 3

TEACHER ATTITUDES TOWARDS NEW IDEAS

STATEMENT ABOUT NEW IDEAS	PERCENTAGE OF SAMPLE
I find new ideas stimulating and attractive.	56.5
I find it challenging to be among the first to test and try new ideas.	25.8
I subscribe to the following position: "Be not the first by whom new things are tried, Yet not the last to lay the old aside."	12.9
No response	4.8
TOTAL	100

Analysis of Part 2 of the Questionnaire

Part 2 of the questionnaire required the teachers to check off answers to ten questions. Space was also provided for the inclusion of further comments related to the given question. In addition, teachers were given the opportunity to list the names of games which they had used in the classroom. The results of the responses to these questions were summarized in a set of tables.

Question 1: FREQUENCY OF USE. A summary of the results of the responses to this question is found in Table 4. Only 5 percent of the sample reported that they had used games more than three times; all of these teachers indicated that they would continue to use games, while one also reported that games were motivating. Apparently those teachers familiar with gaming considered this a worthwhile classroom activity. Further comments by teachers pointed to the need for information about games and gaming; it is the intention of this study to provide teachers with practical information about the use of games for teaching chemistry, as presented in Chapters 5 and 6.

Question 2: KIND OF GAMES USED. A summary of the results of the responses to this question is found in Table 5. The fact that few teachers reported the use of commercially produced games could be the result of the lack of information about games, as discussed above. Further, many of the games used were either developed by the respondent or by a colleague. Shirts (1977) and Glazier (1974) both suggest that "homemade" games are not as successfully used as are the commercially produced ones. This is because the commercial ones have been piloted

TABLE 4

HOW OFTEN GAMES WERE USED IN TEACHING CHEMISTRY

Question 1	Responses to Check	No. of Responses	Percentage of Sample
How much have you used educational games in the teaching of chemistry?	Not at all	32	51
	1 to 2 times in a given chemistry course	27	44
	3 to 5 times in a given chemistry course	2	3
	More than 5 times in a given chemistry course	1	2

TEACHER COMMENTS: Games are too time consuming; would use games if available; not aware of what is available; lack of time and materials to use games; will continue to use games; games are motivating.

TABLE 5

THE KINDS OF GAMES USED BY CHEMISTRY TEACHERS

Question 2	Responses to Check	No. of Responses	Percentage of Sample
Have you used any of the following:	A commercially published educational game	4	6
	A commercially published educational game which you have modified to meet class needs	5	8
	An educational game which you have developed yourself	11	18
	An educational game developed by a colleague	13	21

TEACHER COMMENTS: crossword puzzles and word games used; sources in Chem 13 News and in the ATA Science Council Newsletter; poor students get caught up with the play of the game and lose main objective.

and revised a number of times; this results in consistent games which are successfully played. They also suggest that, while a "homemade" game may work well for its designer, it may not for someone else because the objectives and rules were not carefully communicated; thus these users could be left with negative feelings about games and result in little or no further attempts at gaming. This might be one reason why many of the respondents reported using games only once or twice.

Question 3: TEACHER AWARENESS OF GAMES. A summary of the results to this question is found in Table 6. These results demonstrate that teachers really did not know about games and their availability; thus it is small wonder that half the sample of teachers reported that they had not used games at all. Further, 39 percent of the sample felt that they had already had enough activities for their classes; it would not be likely that these teachers were actively engaged in pursuing other teaching strategies like gaming. However, since the Alberta chemistry curriculum now allows elective units, which give it more flexibility, teachers should be made aware of the potential of gaming, a teaching strategy which might well be incorporated into such units. This is further discussed in Chapter 7.

Question 4: REQUIRED INFORMATION. A summary of the results of the responses to this question is found in Table 7. Teachers were permitted to select more than one response. Since all choices were selected by more than half of the respondents, it was clear that teachers required more information before making use of games for

TABLE 6

CIRCUMSTANCES RELATED TO GAME USE

Question 3	Responses to Check	No. of Responses	Percentage of Sample
Which of the following circumstances apply to you regarding the use of games in teaching chemistry:	I am not aware of the existence of educational games	10	16
	I don't know what games are available	28	45
	I don't know how games can help in teaching chemistry	5	8
	I don't know where to buy educational games for chemistry teaching	14	23
	With labs, and all, I have more than enough activities for my chemistry classes	24	39

TEACHER COMMENTS: time is a premium, but games purchased for future use; games must have a reward; would use games if knew what was available; use would depend on availability of sound games; my slight experience was not very successful; not enough time.

TABLE 7

INFORMATION REQUIRED BY TEACHERS

Question 4	Responses to Check	No. of Responses	Percentage of Sample
To decide whether or not to use games in teaching chemistry, what information DID or WOULD you need to help you to make that decision?	The name and description of the game	48	77
	Names and addresses of suppliers	32	52
	Cost of the games	32	52
	Information on how to use games effectively	41	66
	Summary of research on effectiveness of games in teaching	37	60
TEACHER COMMENTS:	summary of research very important; how do games affect academic performance; cost of game is important, game must be specifically related to course topic; all the above are important.		

teaching chemistry. Seventy-seven percent of the respondents indicated that they required the names of games; such a list appears in Appendix 5. Sixty-six percent of the respondents desired information about how to use games; the Compendium, Chapter 6, provides such information.

Question 5: PURPOSE FOR USING GAMES. A summary of the results of the responses to this question is found in Table 8. Teachers were permitted to select more than one response. Over half of the respondents selected each of the statements directly related to the way in which a game could be used. Several more suggestions were written in: use of games to drill content; use of games to reinforce principles; use of games for variety in teaching. These were incorporated into the compendium of modes of using games, Chapter 6.

Question 6: CRITERIA FOR SELECTING GAMES. A summary of the results of the responses to this question is found in Table 9. Respondents identified several key criteria for selecting a game: the game must involve skill and thinking; the central problem of the game and its objectives must be clear; resources required for game play must be readily available; the central problem of the game must be related to course content. The first three criteria are also identified by professional game designers (Glazier, 1974; Shirts, 1977). The last one is of a more practical nature since it ties in directly with the course content and objectives. These criteria are incorporated into the assessment instrument found in Chapter 5.

TABLE 8

PURPOSES THAT GAMES CAN SERVE

Question 5	Responses to Check	No. of Responses	Percentage of Sample
For what purpose DO or WOULD you use an educational game in teaching chemistry?	For the sake of trying something different	4	6
	To motivate students	39	63
	To help students develop and use concepts	50	81
	To help students develop and use skills (problem solving, observation, interpretation, etc.)	41	66
	To help foster attitudes (curiousity, fascination, co-operation, attitudes toward science, technology and society, etc.)	33	53

TEACHER COMMENTS: a novel way to drill content; good for variety in teaching, use to reinforce principles; the course should be motivating without games; would only use them if they had proven value.

TABLE 9

CRITERIA FOR SELECTING A GAME

Question 6	Responses to Check	No. of Responses	Percentage of Sample
What criteria DO or WOULD you apply in selecting games for use in teaching chemistry?	The rules are easily understood	28	45
	The reading comprehension level is appropriate	27	44
	The game does not require more than two periods	17	27
	The game is physically attractive and durable	20	32
	The game must involve skill and thinking	45	73
	The central problem and objectives are clear	44	71
	The game provides for an evaluation component	21	34
	Resources required for game play are readily available	35	56
	The central problem of the game (its topic) is related to course content	49	79

TEACHER COMMENTS: time should not exceed more than one period (3 responses); relation to course content is of prime importance.

Question 7: WAYS OF USING GAMES. A summary of the results of the responses to this question is found in Table 10. Teachers were permitted to select more than one response. All the ways of using games, except for individualizing instruction, were selected by approximately half the respondents; this indicated that teachers were open to a variety of ways for using games. Hence the compendium of modes of use of games for chemistry teaching, found in Chapter 6, would assist them in planning for the use of games, by pointing to the possibilities available.

Question 8: COMPETITION IN GAMING. A summary of the results of the responses to this question is found in Table 11. Teachers were permitted to select more than one response. Over half the teachers generally favored less competitive situations. Tansey and Unwin (1968) cautioned against putting too much emphasis on competition and winning, lest the purposes of the game become overshadowed by the objective of winning. Teachers, too, showed their general caution about competition.

Questions 9 and 10: ADVANTAGES AND DISADVANTAGES OF GAMES. A summary of the results of the responses to question 9, which dealt with the advantages of games, is found in Table 12; and a summary of the results of the responses to question 10, which dealt with the disadvantages of games, is found in Table 13. Teachers were permitted to select more than one response to each question. Responses to these two questions were quite sporadic, ranging from a low of 6 percent of the respondents to a high of 52 percent of the respondents; this could be due to the fact that half of the respondents had not used games at all

TABLE 10

WAYS OF USING GAMES

Question 7	Responses to Check	No. of Responses	Percentage of Sample
In what ways DO or WOULD you use educational games in teaching chemistry:	As an introduction to new material	28	45
	To drill students in content	31	50
	For review	30	48
	As enrichment	38	61
	To individualize chemistry instruction	14	23
	To change teaching approach	29	47
	To practice problem solving	29	47

TEACHER COMMENTS: Games could also be used to illustrate real problems in scientific research.

TABLE 11

COMPETITION IN GAMING

Question 8	Responses to Check	No. of Responses	Percentage of Sample
In what competitive ways DO or WOULD you use educational games in teaching chemistry?	Competitively: individuals against each other	14	23
	Competitively: individuals against the game	35	56
	Competitively: teams against each other	16	26
	Competitively: teams against the game	19	31
	Non-competitively: individuals playing the game	32	52
	Non-competitively: groups playing the game	18	29

TEACHER COMMENTS: Competition not important, key is relevance and suitability; competition style would depend on the game (3 responses); objective is to learn and not to win.

TABLE 12

ADVANTAGES OF GAMES

Question 9	Responses to Check	No. of Responses	Percentage of Sample
What ADVANTAGES do you see in using educational games?	No advantages	4	6
	Students are motivated	32	52
	Students can gain concepts and ideas easier	26	42
	Students can develop and use skills, such as problem solving, observation, interpretation	30	48
	Games foster attitudes, such as curiosity, co-operation, attitudes toward science	24	39
	Students have more fun and enjoy learning chemistry	26	42

TEACHER COMMENTS: Advantages are not applicable if games used too much in the style of teaching; advantages depend on the nature of the game; joy of learning very important (2 responses); I haven't used games so I can't tell (3 responses).

TABLE 13

DISADVANTAGES OF GAMES

Question 10	Responses to Check	No. of Responses	Percentage of Sample
What do you see as DISADVANTAGES in using educational games?	No disadvantages	7	11
	They take up too much class time	19	31
	They are just a fun break and little is learned	9	15
	Students don't take games seriously	19	31
	Game activities are difficult to evaluate	13	19
	Some students don't like to play games	13	19

TEACHER COMMENTS: none if games are used as a support to course material; cost; upkeep; replacement of parts; no experience, so can't tell (2 responses); no disadvantages, but game must be carefully chosen to serve a purpose (2 responses); disadvantages occur when objectives of game not clear; games can be over-used and lose their effectiveness; disadvantages depend on the game; few games have sound educational value.

and hence felt that they could not speak to the advantages or disadvantages of using games for teaching chemistry. However, motivation was selected most often (52 percent) as an advantage; this is in agreement with proponents of gaming who also claim this to be an important advantage, as reported in Chapter 2. On the other hand, that games take up too much time was one of the chief disadvantages identified by the respondents; 31 percent checked this item, while a further 18 percent made written comments about the time that games take to be played. Clearly this is a concern of teachers that needs to be met. The assessment instrument described in Chapter 5 would help the teacher identify the time required to prepare for the game and to play it. Further, the assessment instrument would help the teacher determine if the game suits the objective in mind. If it turns out that the game is particularly suitable, then it might be well worth the time it takes to use it. To further assist the teacher, there are suggested ways of using the games as found in the compendium of modes, Chapter 6.

Question 11: COMMERCIAL GAMES USED. This question asked the teachers to list the commercial games that they had used. The following games were identified, listed in descending order of frequencies: Chem Bingo; Chem Cubes; Chem Chex; Chem Track; Chem Bees; Building the Periodic Table. The last two were listed only once. (The researcher was unable to find any published evidence for these two games; it is possible that these were games prepared by a fellow teacher and subsequently listed as a commercial game.) Since this is a rather small sampling of the games available (see Appendix 5), it would further serve to support the findings that teachers generally had little

knowledge about games and what was available. This study endeavors to make more information available to the teacher.

Test of the Hypotheses

There were two hypotheses stated about the relationship between the years of teaching experience and post-secondary education and the use of games for teaching chemistry. The chi-square (χ^2) test was used for both hypotheses.

Hypothesis 1: There is no relationship between the years of teaching experience and the use of games for teaching chemistry.

This hypothesis was tested using the χ^2 test for the relationship between years of teaching experience and the use of games for teaching chemistry. Table 14 presents the observed frequencies and the calculated χ^2 value. This observed χ^2 was not significant at the 0.05 level of significance; the null hypothesis was not rejected. Thus years of teaching experience did not appear to be a significant factor in determining the use of games by teachers.

Hypothesis 2: There is no relationship between the number of years of post-secondary education of the teachers and the use of games for teaching chemistry.

This hypothesis was tested using the χ^2 test for the relationship between years of post-secondary education of the teachers and the use of games for teaching chemistry. Table 15 presents the observed frequencies and calculated χ^2 value. This observed χ^2 was not significant at the 0.05 level of significance; the null hypothesis was not rejected. Thus years of post-secondary education of the teacher did not appear to be a significant factor in determining the use of games by chemistry teachers.

TABLE 14

USE OF GAMES AND YEARS OF TEACHING EXPERIENCE
FREQUENCY AND SIGNIFICANCE OF RESPONSES

Use of Games	Frequency of Responses		
	1 - 5	6 - 9	10 and more Years Experience
Not Used	9	9	11
Used More Than Once	5	11	14

χ^2 has an observed value of 1.90

TABLE 15

USE OF GAMES AND YEARS OF POST-SECONDARY EDUCATION OF TEACHERS FREQUENCY AND SIGNIFICANCE OF RESPONSES

Use of Games	Frequency of Responses		
	4	5	6 and more Years teacher education
Not Used	8	14	8
Used More Than Once	11	8	12

χ^2 has an observed value of 2.89

Chapter Summary and Discussion

The survey showed that half of the respondents had not used games for teaching chemistry and that less than 10 percent of them had used games frequently. Several underlying reasons are manifest. First, teachers did not have information about games and gaming; information about gaming as a teaching strategy must be made available to them. Second, a substantial number of teachers stated that they already had enough activities for their chemistry classes. Apparently, these teachers must first be convinced of the value of games for chemistry teaching, followed by making information available. Without information about games and how they can be used, an informed decision about the use of games for teaching cannot be made. Third, a majority of the games used were reported to be of the "homemade" variety. Experts in gaming claim that these are usually filled with problems and pitfalls that make their use frustrating; consequently teachers are discouraged and likely stop gaming. This could explain why some teachers reported using games only once or twice. Information about published games, which have been tested and piloted and are less likely to have internal problems, is also needed (Appendix 5).

Teacher comments written in on the questionnaire fell into four main categories: comments asking for information; prescriptive comments and suggestions; comments expressing reservations about games; general comments. These comments are summarized in Table 16.

The comments requesting information generally reflected the results reported above; teachers did not have much information about games.

TABLE 16

A SUMMARY OF TEACHERS' COMMENTS AND SUGGESTIONS

Comments asking for information

Not aware of what games there are available
Would use games if they were available
Lack of games in school
Require summary of research on gaming
How do games affect academic performance?
I haven't used games so I can't tell

Prescriptive comments and suggestions

Games must have a reward
Games must be sound
Games must be related to course content
Use games to reinforce principles
Games are a novel way to drill content
The time required to play should not be more than one period
Use games to illustrate real problems in scientific research
Competition is not important
The object to learn from the game and not to win
Do not overuse games
Chose games carefully to serve a purpose
Games must be relevant and suitable

Comments expressing reservations about gaming

Cost is a factor
Upkeep and replacement of missing parts
Games take up too much class time
Few games have sound educational value
Poor students get caught up in the play and lose main objective of the game
My slight experience with games was not very successful
I would only use games if they had proven value
Disadvantages occur when the objectives of the game are not clearly stated

General Comments

I've used games (more than 5 times) and they are motivating
Joy of learning is very important
Sources in Chem 13 News and ATA Science Council Newsletter
Use cross word puzzles and word games
The course should be motivating without the use of games

The prescriptive comments fell into two categories: those related to gaming; those related to the game itself. There was concern expressed about the "soundness" of games. Expressions like "proven value" and "few games have sound educational value" demonstrate that some teachers must be convinced about the credibility of gaming before they would consider getting involved. However, since it is not possible to determine from the comments just exactly what constitutes "proven value" or "educational value," specific suggestions cannot be made. Perhaps these comments arose out of a lack of information about games and gaming; the review of the literature, Chapter 2, was intended to provide a basis for gaming and might serve teachers in this way. Comments about gaming indicated that teachers were concerned with the gaming process and how it would affect their classes; for example, the time element was again raised and one period was prescribed as the maximum time that should be used for game play. These concerns are further dealt with in Chapter 6.

Comments expressing reservations about gaming again included the time factor. However, the time required for play varies with the game; therefore, a teacher must determine from the game materials time required for play. The assessment instrument, described in Chapter 5, includes the time component as an assessment factor. The comments about "sound educational value" and "poor students get caught up in the play" were made by teachers who had not used games more than once or twice and who had used "homemade" games. Thus these comments come from within the context of very limited experience with gaming and further point to the need for more information. The assessment instrument also includes some of these teacher concerns.

The general comments were basically of a positive nature. The teacher who reported that he used games more than five times also reported that the students were motivated by games; this is in accord with the reports of proponents of gaming who claimed a high degree of motivation among game players.

Testing of the hypotheses demonstrated that neither years of experience teaching nor years of post-secondary education played a significant role in determining whether teachers use games for teaching chemistry. It cannot be assumed that, through years of experience or teacher education, teachers came into contact with sufficient information about gaming to warrant their using this teaching strategy. The fact that teachers reported knowing little about games and gaming bears this out.

The compendium, Chapter 6, endeavors to provide teachers with information about how they can use games in teaching. The assessment instrument, Chapter 5, is intended to help teachers assess games for their purposes; a teacher may then be more likely to feel that the game has made a contribution to the class and has not wasted time.

CHAPTER 5

THE GAMES ASSESSMENT INSTRUMENT

The purpose of this chapter is to provide the rationale for the development of the Assessment Instrument for assessing the potential of games for chemistry teaching. The developed Games Assessment Instrument is found in Appendix 2. References for the games used as examples are found in Appendix 5.

The Need for an Assessment Instrument

Designers of games have called for the need to assess games for their potential use in the classroom. It is their contention that, given the ever increasing number of games available, a teacher needs some means of assessing them for classroom use. They further contend that not all games live up to their designers' or developers' claims (Dukes and Waller, 1976; Gillespie, 1972). Consequently, some means of evaluation must be made available to teachers so that they can determine if the game has sound design and if it suits their needs. Dukes and Waller (1976) and Gillespie (1972) designed assessment instruments; these instruments were not geared specifically for assessing chemistry games and concentrated mainly on their internal consistency.

The Educational Products Information Exchange (EPIE) Institute was started in 1966 for the purpose of evaluating the potential of

educational materials. It was their contention, too, that educational products did not live up to the claims made for them by their manufacturers. They saw the need for an independent organization to assess materials and to make subsequent information available to consumers. This need for assessment of educational materials has been underscored by the many agencies that rely on EPIE evaluations as a means for selecting materials for their schools.

The Games Assessment Instrument

The assessment instrument was designed to be used by teachers to assess the potential of games for classroom use. There were two key sources for criteria of assessment: teachers' comments and concerns as identified on the questionnaire, particularly questions 5 and 6; and game designers' criteria for a "good" game (Duke and Waller, 1976; Shirts, 1977; Gaines, 1973; Gillespie, 1972). Consequently, the assessment instrument was longer than would be convenient for general teacher use, that was necessary to cover the varied concerns. However, a teacher may use only parts of the instrument, depending on the needs and the type of game being assessed. A suggested abridged version is found in Appendix 6.

The assessment instrument (Appendix 2) was submitted to seven chemistry teachers and the researcher's advisor for scrutiny; it was subsequently revised and the shorter version was prepared. However, to ascertain the validity and value of such an instrument would require extensive piloting and revision, matters beyond the scope of the present study.

The instrument is modeled on the EPIE Instructional Materials Design Analysis Instrument (1977). Their evaluation instrument has been tested and used by evaluators throughout North America and has been proven to be most useful for the evaluation of instructional materials. The EPIE materials and evaluations have come to be accepted both by evaluators and consumers of educational materials (The American School Board Journal, January, 1975, pp. 38-41).

The games assessment instrument has three parts, based on the EPIE categories: description and physical characteristics; the antecedents or necessary prerequisites for gaming; the internal consistency of the games. Use requires short written answers or the checking of appropriate choices. Responses are either obtained directly from the game materials or must be inferred from the materials by the teacher.

Part I deals with the description of the game and its physical characteristics. Included are: title, copyright date; publisher; supplier; physical description; durability. Cost, availability, and replacement parts were identified by respondents to the questionnaire. These are criteria not generally mentioned by game evaluators; they are included in the EPIE evaluation form for the purpose of complete description of the materials being assessed.

Proponents of gaming identified a number of different game formats: simple paper and pencil games, like crossword puzzles or word games; card games, like Precipitate, which use cards as the medium for studying some 'real' aspect of chemistry; board games, like Chem Bingo, which could also use such things as spinners, dice or moving pieces; games which involve role play; games using other manipulatives, like original scientific papers, or some gadgets specifically designed for

the game, like the Hypothesis Machine; computer simulations, which are not included in this study. These game formats are included in Part I of the assessment instrument under the category of game medium (Tansey and Unwin, 1968; Gordon, 1970; Spencer, 1977).

Complete information in Part I of the assessment instrument is especially necessary if a teacher is examining games sent to him on approval and comparisons are being made with a view to purchase one or more games. However, when a game is already available for the teacher's use, then some of the details, like cost or publisher, are not of particular value. Such categories could then be left blank.

Part II of the assessment instrument deals with the antecedents, that is, those necessary prerequisites for the use of the game. (The more complex a game, the more preparation and planning is required.) Categories in this part are also designed to assist the teacher in determining how well a game suits his needs. Included for this purpose are categories like: relation of the game to curriculum; grade level; difficulty level; specific topic (central problem of the game); intended learner outcomes. The central problem of the game and the intended learner outcomes have been identified by game experts (Gillespie, 1972) as the key to effective gaming; they should be easily identified. Curriculum role and time required for play were criteria identified by respondents to the survey questionnaire.

Items in this part would be of use to teachers in most instances. Simple games, whose intents are obvious, may not require such detailed scrutiny; an example would be the use of a crossword puzzle to drill some content material. However, it is still important to know what

background students require to be able to handle the puzzle without frustration, the content covered and its relation to what has been done in class, as well as the grade level and difficulty of the game. The categories in this part of the assessment instrument alert the teacher to these aspects.

Part III is concerned with the internal consistency of a game. These categories were mainly those identified by game experts (Duke and Waller, 1976; Gillespie, 1972). Concerns voiced by respondents to the survey questionnaire were also included. Although the internal consistency of educational materials is also an EPIE concern, their categories are not specific enough for game evaluation.

Gillespie (1972) identified six key elements which combine to form the "knowledge base" of a game. These elements are: (1) The central problem of the game. (2) The choices available to the players. (3) The activities or moves provided for the players. (4) The rules of the game. (5) The organization of the game. (6) The summary activities of the game. These elements interact to form the knowledge base of the game. Gillespie (1972, p. 34) describes this interaction:

> Therefore (the six elements) . . . are not much help to the teacher singly, but together they provide an accurate picture of the knowledge base of a game. A knowledge base is built upon a problem statement. From that statement the essential concepts and principles are transformed into choices, moves, and rules in game play. The choices and moves are organized in a way that effectively or ineffectively guides the players to learn about the basic concepts and principles. The summary activities of a game determine whether or not the game can achieve its purpose in the final outcome.

She also offers criteria for judging the elements of a game; these are discussed below.

The central problem helps to give the game its direction. It

must be clearly stated and conceptually rich; a general, bare statement is of little use in giving direction to the game. The central problem must have utility; that is, it must direct the players toward the attainment of specific outcomes. Finally, the central problem must be related to reality. These criteria are reflected in Item 1 of Part III of the assessment instrument. Also included were concerns expressed by respondents to the survey questionnaire. These included the relation of the game to course content and soundness of the game. Categories like "Are the statements accurate"? and "Are there any factual errors"? are also EPIE criteria.

The next three elements, choices, rules, and moves, were evaluated using the criteria of soundness, consistency, and lack of distortion. To be sound, choices had to be directly related to the central problem. The activities or moves had to be presented in ordered, consistent sequences of behavior which arose out of meaningful decisions. The rules must be clearly stated, easily understood, and related to the central problem; insofar as possible, the rules must mirror reality. Respondents to the survey questionnaire were concerned that games should be more dependent on skill for their play than they are dependent on chance. These concerns and criteria were reflected in Items 2 and 3 of Part III of the assessment instrument.

Organization of the game can be judged using two criteria: inclusiveness and sequencing. The inclusiveness criterion pertains to all players having an opportunity to make important decisions; such decisions should not rest solely with one player or group of players. The sequencing relates to the allowing of sufficient time and

opportunity for the players to consider the major learning aspects of the game. These criteria are also included in Item 3 of the Assessment Instrument.

Summary activities should bring out what students have learned from the game. The summary must be related to the central problem statement and the activities of the game; application to "real life" must be made. These criteria are reflected in Item 4 of Part III of the assessment instrument.

Summary

The assessment instrument includes concerns and criteria suggested by teachers, professional evaluators of educational materials, and game experts. It was modeled in the main after a proven evaluation form developed by EPIE. The chief criticism by those asked to review it was that it was too long for convenient teacher use. An example of an abridged version is found in Appendix 6. Abridgement will depend on the needs of a teacher and the type of game being evaluated. A teacher can select whatever parts are most meaningful for the given circumstances and needs. For example, if a teacher were assessing a game already purchased, then details in Part I could be reduced to title, medium and format. Piloting and revision of the instrument were beyond the scope of the present study.

The long form (Appendix 2) could be used by teachers for selecting a game for class use from among those already available; the completed form may be kept on file for later reference and use. It could also serve to aid teachers in making decisions about the purchase of games; many suppliers and manufacturers make materials available

on approval, so that they can be reviewed, assessed, and returned if not suitable.

The categories represented are sufficiently detailed to ensure that key areas of concern are covered. Use of the assessment instrument will assist teachers in selecting games which meet not only a prescribed set of criteria, but also the needs of the class. Hopefully more successful gaming will result.

CHAPTER 6

A COMPENDIUM OF MODES OF USING GAMES FOR TEACHING CHEMISTRY

The purpose of this chapter is to propose a concise set of modes of game use for teaching high school chemistry; this set is referred to as the Compendium. It is preceded by some general suggestions for gaming. References for the games used as examples are found in Appendix 5; these games are for example only and do not imply an exhaustive listing.

Suggestions for Gaming

Proponents of gaming, like Gordon (1970) and Glazier (1974), claim that a teacher must be carefully prepared if gaming success is to be optimized. Clearly, the more complex and involved a game is, the more preparation is required of the teacher. However, one basic preparation procedure holds true regardless of the complexity of the game. The teacher must choose a game which meets the needs and objectives of the topic in question, as closely as possible. One of the intents of the Assessment Instrument (Appendix 2) was to assist the teacher in this task. Completing this instrument for a given game would go a long way in preparing the teacher for using the game.

There are three phases that the teacher must plan: the pre-game briefing; playing the game; the post-game debriefing session. However, the preparation required for a card game like Chem Rummy,

where students use cards to make correct chemical formulae, is certainly much less than the preparation required for playing The Amsyn Problem, a role-playing game based on the environmental and community problems caused by a small chemical company. Gordon (1970, p. 112) makes some suggestions to help the teacher plan for playing the game:

1. If possible, play the game through with other teachers or friends.
2. Become acquainted with the physical components of the game.
3. Thoroughly read the materials provided for the teachers' use.
4. Modify the game, if necessary, to meet particular needs of the class.
5. Decide the basis on which roles will be assigned. Try to include bright and slow students on the same teams.
6. Distribute copies of the rules and profiles, and scenarios where they are used, to each student the day before the play.
7. Arrange the components of the game in the classroom.
8. Brief the students on:
   a. the purpose of the game.
   b. the roles of individuals or teams, and objectives.
   c. the physical layout of the room.
   d. the first move.

   This phase should not exceed fifteen minutes.
9. During the play circulate among the groups or individuals and offer suggestions where desirable, answer questions when necessary. Try to involve the student in answering his own questions and arriving at solutions.

Whereas the above planning suggestions make for better gaming, the debriefing session at the end of the game is particularly important, especially for complex, role-play games. Here the teacher has a

more dominant role in synthesizing the process depicted by the game. In the debriefing discussion the teacher must again review the objectives of the game and relate them to the game activities. For the more complex games, questions dealing with the following aspects can be useful in helping the teacher integrate the game and its outcomes into the class work: Why were actions taken and what were their effects? Were actions fair? What about the interactions between players, negotiations and the element of luck? How did uncontrollable events fit into the process and effect the final outcome? A successful debriefing will help the players to better understand their actions and how they were related to the process of the game (Glazier, 1974; Gordon, 1970; Tansey and Unwin, 1968)

However, many of the chemistry games available are of the simpler, content oriented variety (Appendix 5). These do not require such an elaborate debriefing session since they did not involve complex and varied interactions among the players. Yet to be effective, the teacher must be familiar with the game and its play and be able to help students relate it to their class work.

The Compendium of Teaching Modes

The Compendium was prepared to give chemistry teachers a concise guide to the various ways in which games could be used for teaching chemistry. There were several sources of information for the compendium. First, teacher responses to the survey questionnaire; questions 5, 7 and 8 were specifically directed to this area. Second, the manuals which accompany published games also provide some information on the ways in which games could be used for teaching. Third, ideas

came from literature sources, like Gordon (1970), Tansey and Unwin (1968) and Spencer (1977). In order for the Compendium to be more directly useful to teachers, examples of specific games were also included; more games are listed in Appendix 5. The categories are those which teachers normally consider when planning chemistry lessons.

1. Games for Introducing a Unit. Gordon (1970) suggested that games could be used as a means of introducing students to a new unit or concept. However, it is important to determine what the required entry competencies of the players are; this is one of the criteria in the Games Assessment Instrument (Appendix 2). Not all games are suitable for this purpose, especially if they focus on drill or alternately rely heavily on new and unfamiliar material. During the play of a game, students may be introduced to issues or problems which will be dealt with in the new unit of study. For example, The Pollution Game could be used to introduce students to the elective unit Environmental Problems in Chemistry 30. This game is designed to have students "experience" the increase of pollution due to industrialization. Having used the game to introduce students to the problems of pollution, they then study, in greater depth, some of the effects on the environment, like the greenhouse effect and thermal pollution.

2. Games for Drill and Practice of Content. Many of the chemistry games contain these elements (Appendix 5). For example, Chem Cubes is a game designed to reinforce and practice the basic skills regarding elements and the periodic table. The game uses cubes, like dice, with symbols of the elements on them. One variation of the game requires students to determine the names of the elements whose symbols they have rolled. Another variation requires the player

to identify a rolled element according to its position in the periodic table. For example, if Zn (zinc) is rolled, it would be identified as a transition element in the fourth period. This game would be played after students in Chemistry 10 had been introduced to the periodic table; the periodic table is a necessary component of the game not supplied by the designer. Robert Gang, the designer of Chem Cubes, suggests in the game manual that games such as these could replace written homework assignments. Another variation of these games are the puzzles and word games found in the Alchem chemistry course; these too drill content and can be used for homework. Many of these games are of short duration and could be played several times in one class period.

3. To Individualize Instruction. Game designers, like Robert Gang (Chem Cubes game manual) claim that games can be used to help to reinforce content. Here both individuals or small groups with similar backgrounds could be involved. If a student required more contact with, for example, the periodic table, then a game like Chem Cubes could be used by that student. If a student required more contact with some topic, then a game related to that topic would be used. Students of above average abilities could be given more challenging games. The Games Assessment Instrument could assist a teacher in determining how a particular game would fit the student's needs. Gang also suggests that the game could be used like a student's tutor by providing him with a means of going over material as required.

4. Games for Process Skill Development. Process skills are important in science education; therefore, Nay and Associates (1971)

had prepared an inventory of these scientific processes. Some designers claim that their games can be used to develop such skills. The Amsyn Problem is a role-playing game, with a distinct chemistry orientation, which is intended to develop skills in problem solving, decision making, and argument development and presentation. The specific process skills involved, identified according to the Nay inventory, are: identifying the problem and seeking relevant background information; predicting; collecting data; interpreting the data. There appears to be a high level of inquiry throughout. The problem centers around a small chemical company which has new standards of pollution control imposed upon it; these would be financially disasterous to the company, resulting in closure. Since the community is dependent on this company for employment and other business, all stake holders become involved in attempting to find a solution. All groups study the problem from their perspective and propose solutions, backed by appropriate data. Since this is a rather complex and involved game, it could take a number of class periods for preparation and completion.

A simpler game, In-Quest, is also intended to develop such skills as identification, prediction and observation. Players are required to analyze an argument and to detect errors in the reasoning. Although this is not specifically a chemistry game, it can be used to direct students to these skills; it might be appropriate to use this game in the first unit of Chemistry 10 when these scientific skills are first introduced.

In the post-game discussion the teacher should help students

recognize the various skills used in the game. How were these skills used in selecting, evaluating and applying information in relation to the central problem of the game? This question becomes the focal point of this discussion; it will be necessary to help the students identify any remarks, attitudes, procedures or conclusions that illustrate the skills involved.

5. Games for Attitude Development. Proponents of gaming claim that games can be used not only to help students develop a positive attitude towards their studies but also to develop specific attitudes. For example, in The Amsyn Problem social, economic and even moral considerations affected a "purely chemical" decision. (A reacts with B giving a higher yield of purer product, but a by-product could also be a danger to the environment. The best reaction is not used, although it makes the most sense from a chemical point of view.) That the scientist cannot always make decisions based purely on scientific evidence, is demonstrated.

The teacher could pinpoint scientific attitudes by asking appropriate questions in the post-game discussion. Some of these attitudes and suggested questions are (Kozlow and Nay, 1976):

Objectivity: Was all available data considered? Were the ideas of others considered?

Willingness to change opinion: Was new data used to alter hypotheses or opinions? Were the ideas of others recognized and evaluated?

Open-mindedness: Were both pros and cons considered when decisions were made? Were ideas or opinions of others considered and evaluated?

Critical mindedness: Were inconsistencies of statements or conclusions identified? Were unsupported statements challenged?

Respect for evidence: Was data collected before conclusions were drawn? Was evidence supplied to back up conclusions?

Honesty: Was the work of others acknowledged? Was all the evidence considered?

6. Games for Inquiring into Scientific Inquiry. Schwab (1962) contends that one of the most powerful teaching strategies is inquiry into scientific inquiry; in this way students learn about science as a process of inquiry. Even though this is an important aspect of science education, there are no games that specifically relate to this area. However, there are some suggestions that can be made. Background material could be obtained from original scientific papers; many of the early papers were written in a personal, non-technical style. A scenario could be developed, based on a particular paper; roles could be assigned and the situation could then be acted out. Observers would be asked to identify the following: the problem being studied; how information was selected, evaluated and applied to the problem; recognize the hypothesis formulated; recognize and evaluate conclusions; assumptions and generalizations; describe the scientist in terms of the process skills used in approaching the problem; recommend areas requiring further study. In this way students would be given an insight into the work of the scientist. It is recommended that games in this area should be developed and made available to chemistry teachers.

Discussion and Summary

The purpose of this chapter was to suggest a concise set of ways in which games could be used for teaching high school chemistry. The way that the Alberta chemistry curriculum is now organized, with the required core and suggested elective units, gives the program much more flexibility. Teachers should no longer find themselves pressed for time to complete the required course of studies. There is even an allowance for locally developed elective units. Thus the teacher has the time to be more creative with his chemistry teaching. One way in which to take advantage of this, is to incorporate gaming into the activities. Games could become a basis for an elective unit. For example, The Pollution Game could be played to introduce students to the problems of industrial pollution, these problems could then be studied in depth and then the game played again to see if students' decisions would be affected by their new found insight into the problems. A somewhat different approach might be to have the students study a topic in detail and then design a game which relates to this topic. The teacher would have to remind the students of the following aspects: the central problem must be stated clearly and be related to the "real world;" rules should be simple and related to the problem; there should be a distinct element of skill; all players should have an equal opportunity to make decisions and play the game. The development of a game requires that students become thoroughly familiar with their topic; it also allows for student creativity. (It has been the limited experience of the researcher that this latter approach is enthusiastically accepted by high school students, Chemistry 30 level, and

has resulted in a better understanding of the given topic, as reported by those students participating in this activity.)

Many of the games designed specifically for chemistry are of a drill and practice of material nature. Some games from other areas, like biology, relate to such topics as pollution and energy and can thus be used when studying these topics. There is a distinct need for the development of games that deal with such things as process skills, inquiry into scientific inquiry and attitude development.

The modes that were presented reflected the ideas of gaming experts, game designers and science educators. It is necessary, however, to further explore these approaches to using games for teaching chemistry through actual classroom interaction and to assess the effectiveness of the games in these area; these are beyond the scope of the present study.

CHAPTER 7

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary and Conclusions

The study centered around three key parts: the survey of high school chemistry teachers in Edmonton to determine the extent and mode of use of games for teaching chemistry; the development of an assessment instrument to help teachers assess games for use in chemistry classes; the development of a concise collection of ways in which selected games could be used to teach chemistry, called the compendium.

The review of the literature pointed to a number of things:

1. Games have been part of civilization for centuries.
2. War games have developed over the years to become highly sophisticated and successful in the twentieth century.
3. Business games developed from war games and educational games, in turn, developed from business games.
4. The social sciences were the first to accept and extensively use games for teaching.
5. Research on educational gaming is still in its infancy and is plagued with shortcomings that must be resolved.
6. The research findings were generally mixed, with some support for the motivational and affective aspects of gaming, but no significant advantage in the cognitive area.

7. The trend in science education is away from the subject matter orientation and towards the responsibilities of science to society.
8. The present Alberta chemistry curriculum reflects this trend.
9. Games are being considered by some science educators as one teaching strategy to be useful for dealing with affective development. Consequently, they believe that games are becoming more widely accepted by science teachers.
10. The chemistry teacher, too, can make use of gaming as one strategy in his repertoire of teaching skills.

The results of the survey indicated that chemistry teachers had not used games to any great extent. Further, they were in need of information about gaming, games available to them and how games could be used in the chemistry classroom. Two hypotheses were proposed and tested using the chi-square statistic (χ^2); the observed χ^2 value for both hypothesis was not significant. Therefore it cannot be assumed that a teacher, through years of experience or education, would come into contact with sufficient information about gaming to warrant its use. Specific information about gaming and its use in the chemistry classroom is needed. The assessment instrument is intended to be used to help teachers select appropriate games for their purposes; the compendium of modes is intended to provide information about ways in which games could be used for chemistry instruction. It is hoped that these sources of information will assist teachers so that successful gaming will result. It should be noted that the survey sample was not

randomly selected from chemistry teachers throughout Alberta, but rather included the majority of chemistry teachers from Edmonton high schools. Therefore any generalizations which go beyond this sample should be viewed with caution.

The survey questionnaire was piloted and submitted to a panel of judges to determine face validity. The survey was kept relatively short and designed to further reduce the common problems associated with the questionnaire's validity. There was a high rate of return of completed questionnaires.

Both game users and designers pointed to the need for some means of assessing games for use in the classroom. As well, respondents to the questionnaire raised some concerns about games and offered criteria for assessing them. These criteria, along with those offered by gaming experts and curriculum evaluators, were incorporated into a games assessment instrument (Appendix 2); the instrument was patterned, in the main, after a proven format designed by the EPIE associates.

The instrument has three parts: Part I, description of the game; Part II, description of the required prerequisites for game play; Part III, description of the internal consistency of the game. Responses were either short answer or checks from a list; the answers to questions could be obtained directly from game materials or might have to be inferred by the teacher. The instrument could be used when assessing and comparing games for purchase; this is made possible when suppliers provide games on approval. It is also helpful for selecting a game for class use. The completed instrument could also serve as a permanent record of the game in the teacher's file or in a resource center.

It was not possible to extensively field test the instrument; this was beyond the scope of the present study. However, it was submitted to a panel of judges for assessment and subsequently revised. The main criticism was that the instrument was too long for convenient teacher use; however, this was necessary in order to incorporate the main assessment criteria for a complete picture of the game. A teacher could, however, abridge the instrument by using those categories which are most meaningful and helpful for the particular purpose in mind. A suggested abridged version was also prepared by the researcher (Appendix 6).

The compendium of modes of use of games for teaching high school chemistry is a concise collection of ways in which games could be used. Suggestions were taken from the survey questionnaire, from game materials, and from gaming experts. The compendium was also submitted to a panel of judges and subsequently revised. Included are the following suggestions: games for introducing material; games for drill and practice of content material; games for individualizing instruction; games for process skill development; games for attitude development; games for inquiry into scientific inquiry. (Since there were no games specifically designed for the latter mode, some suggestions were made for the development of such games.) The greater flexibility of the present Alberta chemistry curriculum should allow for more teacher creativity. It is hoped that teachers will use this opportunity to incorporate gaming into their chemistry program. Field testing these modes was beyond the scope of this study.

It is hoped that the information in this study would assist

chemistry teachers so that they would become familiar with available games and gaming, comfortable with their use, and so add another teaching strategy to their repertoire of skills.

Suggestions for Further Study

1. Variety of Chemistry games. There is a definite need for the development of more diverse, good quality chemistry games. (Many of those available are for drill and practice.) Games for the purpose of process skill development, attitude development and for inquiry into scientific inquiry are especially needed.

2. Research on gaming. There is a definite need for research on gaming in science (chemistry) classrooms. Areas of concern include: effectiveness to motivate students beyond the gaming activity; effectiveness of games to develop process skills and attitudes; effectiveness of games to teach content material.

3. Source of available games. There is a need to establish some system, like the ERIC system, for collecting and listing information about the chemistry games that are available. This would give the teacher ready access to information about available games.

4. The Games Assessment Instrument. There is a need to field test the instrument so that any necessary revisions could be made which would make the instrument more useful and meaningful for teachers.

5. The compendium of modes. Since these suggestions deal directly with the classroom interactions, it is necessary to field test them and to further refine them. It is here, in the classroom, where the success of gaming is determined; therefore, the ways in which games are used is very important.

6. The value of developing games. There is a need to study the benefits that developing a game could have for the developer, teacher or student.

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APPENDICES

APPENDIX 1

SURVEY QUESTIONNAIRE

Harry P. Klann
Department of Education
The University of Alberta
Edmonton, Alberta
May 27, 1977

Dear Chemistry Teacher:

All of us, at one time or another, have looked for a new or different approach to the teaching of chemistry. However, practical information is not always readily available. One such teaching approach involves the use of educational games. Much has been written about educational games, but little, specifically, for the teaching of chemistry.

I have undertaken to put together information about educational games, their potential and use, geared specifically to the teaching of chemistry; this project is a part of my thesis work, under direction of Dr. M. A. Nay. Information about educational games and how they are being used is needed. With this in mind, a questionnaire has been prepared and is enclosed in this letter.

Please take fifteen minutes of your time to complete the questionnaire, then return it to by Friday, June 3rd. I will be picking them up at that time. Your replies will be kept strictly confidential.

Thank you for the courtesy of your assistance!

Yours truly,

Harry P. Klann
Phone: 479-3155

HPK/eh

enclosure

A STUDY OF THE USE OF EDUCATIONAL GAMES IN TEACHING HIGH SCHOOL CHEMISTRY: A TEACHER QUESTIONNAIRE

I. PART I. PERSONAL INFORMATION

Please fill in the following personal information.

1. Male ___ Female ___
2. The number of years of university education___
3. The number of years teaching ___
4. The number of years teaching chemistry ___
5. The number of teachers in your high school ___
6. The number of teachers teaching chemistry in your high school ___
7. Besides chemistry, what other subjects did you teach this year?

   _____

   _____

   _____

8. Please check one of the following statements that best describes you.

   ( ) I find new ideas stimulating and attractive.

   ( ) I find it challenging to be among the first to test and try new ideas.

   ( ) I subscribe to the following position:

   "Be not the first by whom new things are tried,
   Yet not the last to lay the old aside."

* * * * *

Thank you for the personal information. Please proceed to PART 2 which deals with information about the use of educational games in teaching chemistry.

II. PART 2

WHEN ANSWERING THE QUESTIONS IN THIS SECTION, PLEASE KEEP IN MIND THE DEFINITION OF AN EDUCATIONAL GAME AS GIVEN BELOW:

An education game is an activity which imitates real circumstances and aims to teach skills, content, and/or attitudes. It may incorporate rules, a time span, and competition. Playing the game or gaming involves such things as a game board, cards or dice; or, it may involve people playing roles in a given setting; or it may be a combination of these.

PLEASE ANSWER THE FOLLOWING QUESTIONS BY PLACING A CHECK MARK IN THE APPROPRIATE SPOT. THERE IS ROOM AT THE END OF EACH QUESTION FOR YOUR COMMENTS ABOUT ASPECTS OF USING GAMES IN TEACHING CHEMISTRY.

* * * * *

1. How much have you used educational games in the teaching of chemistry?

( ) Not at all

( ) 1 to 2 times in a given chemistry course

( ) 3 to 5 times in a given chemistry course

( ) More than 5 times in a given chemistry course

Comments: _____

2. Have you used any of the following? (You may mark more than one response.)

( ) A commercially published educational game

( ) A commercially published educational game which you have modified to meet class needs

( ) An educational game which you have developed yourself

( ) An educational game developed by a colleague

( ) Other (please specify)

_____

_____

_____

Comments: _____

_____

_____

3. Which of the following circumstances apply to you regarding the use of games in teaching chemistry? (You may mark more than one response.)

( ) I am not aware of the existence of educational games

( ) I don't know what games are available

( ) I don't know how games can help in teaching chemistry

( ) I don't know where to buy educational games for chemistry teaching

( ) With labs, and all, I have more than enough activities for my chemistry classes

( ) Other (please specify)

_____

_____

_____

Comments: _____

_____

4. To decide whther or not to use games in teaching chemistry, what information DID or WOULD you need to help you to make that decision? (You may check more than one response.)

( ) The name and description of the game.

( ) Names and addresses of suppliers.

( ) Cost of the games.

( ) Information on how to use games effectively.

( ) Summary of research on effectiveness of games in teaching.

( ) Other (please specify)

_____

_____

_____

Comments: _____

_____

5. For what purpose DO or WOULD you use an educational game in teaching chemistry? (You may check more than one response.)

( ) For the sake of trying something different.

( ) To motivate students.

( ) To help students develop and use concepts.

( ) To help students develop and use skills (problem-solving, observation, interpretation, etc.)

( ) To help foster attitudes (curiosity, fascination, cooperation, attitudes toward science, technology and society, etc.)

( ) Other (please specify)

_____

_____

_____

Comments: _____

_____

6. What criteria DO or WOULD you apply in selecting games for use in teaching chemistry? (You may check more than one response.)

( ) The rules are easily understood

( ) The reading comprehension level is appropriate

( ) The game does not require more than two class periods

( ) The game is physically attractive and durable

( ) The game must involve skill and thinking

( ) The central problem and objectives are clear

( ) The game provides for an evaluation component

( ) Resources required for game play are readily available

( ) The central problem of the game (its topic) is related to course content

( ) Other (please specify)

_____

_____

_____

Comments: _____

_____

7. In what ways DO or WOULD you use educational games in teaching chemistry? (You may check more than one response.)

( ) As an introduction to new material

( ) To drill students in content

( ) For review

( ) As enrichment

( ) To individualize chemistry instruction

( ) To change teaching approach

( ) To practice problem solving

( ) Other (please specify)

_____

8. In what competitive ways DO or WOULD you use educational games in teaching chemistry? (You may check more than one response.)

( ) Competitively: individuals against each other

( ) Competitively: individuals against the game

( ) Competitively: teams against each other

( ) Competitively: teams against the game

( ) Non-competitively: individuals playing the game

( ) Non-competitively: groups playing the game

( ) Other (please specify)

_____

_____

_____

Comments: _____

_____

9. What ADVANTAGES do you see in using educational games? (You may check more than one response.)

( ) No advantages

( ) Students are motivated

( ) Students can gain concepts and ideas easier

( ) Students can develop and use skills, such as problem solving, observation, interpretation

( ) Games foster attitudes, such as curiosity, co-operation, attitudes toward science

( ) Students have more fun and enjoy learning chemistry

( ) Other (please specify)

_____

_____

_____

Comments: _____

_____

10. What do you see as DISADVANTAGES in using educational games? (You may check more than one response.)

( ) No disadvantages

( ) They take up too much class time

( ) They are just a fun break and little is learned

( ) Students don't take games seriously

( ) Game activities are difficult to evaluate

( ) Some students don't like to play games

( ) Other (please specify)

_____

_____

_____

Comments: _____

_____

11. Please list the names of published games that you have used in teaching chemistry. (If you do not have enough room, please continue on the back of this page.)

_____

_____

_____

_____

_____

_____

THANK YOU FOR YOUR TIME AND THE INFORMATION THAT YOU HAVE PROVIDED. IF YOU WOULD LIKE TO HAVE THE RESULTS OF THIS QUESTIONNAIRE, PLEASE FILL IN YOUR NAME AND ADDRESS BELOW:

NAME: _____

ADDRESS: _____

_____

_____

APPENDIX 2

THE GAMES ASSESSMENT INSTRUMENT

AN INSTRUMENT FOR ASSESSING CHEMISTRY GAMES

DIRECTIONS FOR USE:

The instrument is particularly useful for assessing unfamiliar and complex games for teacher use; it also can serve as a permanent record of a game in either the teacher's file or in a central resource area. The evaluator should study the materials of the game and use this information for answering the items on the instrument. Answers may be directly provided by the game materials or they may have to be inferred from an analysis of the game

PART I: THE CHARACTERISTICS OF THE GAME

1. TITLE: _____
2. AUTHOR(S) _____
3. PUBLISHER _____
4. COPYRIGHT DATE _____
5. AVAILABILITY: (Check appropriate categories)
   - ( ) in school
   - ( ) central office
   - ( ) local supplier _____
   - ( ) other (specify) _____
6. COST _____
7. MEDIUM: (check appropriate categories)
   - ( ) game board
   - ( ) cards
   - ( ) booklets
   - ( ) paper and pencil
   - ( ) manipulatives specific to this game (dice, spinners, etc.)

     _____
   - ( ) role play
   - ( ) other (specify) _____

8. FORMAT (check more than one)

( ) Individual play

( ) Group play; maximum number of players: _____

( ) Role playing

( ) Manipulatives (board, dice, cards, etc.)

( ) Competition: _____

9. PHYSICAL APPEARANCE AND DURABILITY OF MATERIALS

_____

_____

_____

_____

10. ARE REPLACEMENT PARTS READILY AVAILABLE?

(For items used up during play or items readily lost or broken.)

_____

_____

_____

11. ADDITIONAL COMMENTS

_____

_____

_____

PART II: THE ANTECEDENTS

DIRECTIONS FOR USE:

The antecedents are those prerequisites on the part of the teacher, students, and curriculum, necessary for use of the game. Items in this part will also assist in determining how well a game is suited for class needs. Responses are to come from the information found in the materials or inferred from an analysis of the game materials.

1. SUBJECT AREA _____

2. CORE _____ ELECTIVE _____

3. SPECIFIC TOPIC OR CENTRAL PROBLEM OF THE GAME

_____

_____

_____

_____

4. TIME REQUIRED FOR ADEQUATE PLAY (MINUTES) _____

5. RESOURCES REQUIRED TO PLAY THE GAME
(size of room, chairs, tables, paper, other things not supplied with the game)

_____

_____

_____

_____

_____

6. INTENDED USERS (ability range, motivational level, etc.)

_____

_____

7. GRADE LEVEL(S) OF INTENDED USERS: _____

8. DIFFICULTY LEVEL (check appropriate categories)

Intellectual challenge	___high	___medium	___low
Background required	___high	___medium	___low
Level of inquiry	___high	___medium	___low

OTHER: _____

_____

9. LEARNING OUTCOMES TO BE ACHIEVED (either stated or inferred)
(check appropriate categories)

( ) Learning content

( ) Process skill devlopment

( ) Scientific attitude development

( ) Values education (ethics)

( ) Learning about the nature of science

( ) Psychomotor skill development

( ) OTHER: _____

_____

_____

10. ENTRY COMPETENCIES OF THE STUDENTS (Are there any particular skills or knowledge, indicated or inferred, required to play the game?)

_____

_____

_____

11. ENTRY COMPETENCIES OF THE TEACHER (Are there any skills or knowledge, indicated or inferred, that the teacher must possess in order to direct the game?)

_____

_____

_____

12. COMMENTS

_____

_____

_____

_____

PART III: THE PROCESS

DIRECTIONS FOR USE:

This part deals with the internal consistency of the game. Criteria are presented. Responses to these criteria are to be taken from the game materials or inferred from the content of the game materials.

1. THE CENTRAL PROBLEM OF THE GAME (Check appropriate category)

The central problem is clearly stated:

( ) high; ( ) medium; ( ) low

The central problem is related to the real world and is plausible

( ) high; ( ) medium; ( ) low

The central problem is related to the content of the course

( ) high; ( ) medium; ( ) low

The central problem is related to the outcomes of the game

( ) high; ( ) medium; ( ) low

The central problem is accurately stated; no factual errors.

( ) high; ( ) medium; ( ) low

OTHER_____

_____

_____

2. THE RULES OF THE GAME (Check appropriate category)

Rules are clearly stated and easily understood.

( ) high; ( ) medium; ( ) low

Rules are clearly congruent with the central problem.

( ) high; ( ) medium; ( ) low

Rules are related to reality.

( ) high; ( ) medium; ( ) low

Rules allowance for skill and chance

( )1 ( )2 ( )3 ( ) 4 ( )5
(high degree of chance) (high degree of skill)

OTHER: _____

_____

COMMENTS: _____

_____

3. POSSIBLE CHOICES, MOVES, OR ACTIVITIES OF THE PLAYERS (Check appropriate category)

They are related to the central problem of the game

( ) high; ( ) medium; ( ) low

They are plausible in terms of what could happen in reality

( ) high; ( ) medium; ( ) low

They are presented in ordered, consistent sequences of behavior
( ) high; ( ) medium; ( ) low

All players have the opportunity to make decisions and to participate
( ) high; ( ) medium; ( ) low

There is sufficient time for key decisions and attaining game's goals
( ) high; ( ) medium; ( ) low

OTHER: _____

_____

COMMENTS: _____

_____

4. THE GAME'S SUMMARY ACTIVITIES (Check the appropriate category)

They pull together or summarize the activities and outcomes

( ) high; ( ) medium; ( ) low

They answer the central problem of the game

( ) high; ( ) medium; ( ) low

They relate the outcomes to reality

( ) high; ( ) medium; ( ) low

OVERALL EVALUATION OF THE GAME: (Check appropriate categories)

The game is durable and appears suitable for student use

( ) high: ( ) medium; ( ) low; ( ) does not apply

The game is related to course content and objectives

( ) high; ( ) medium; ( ) low

The game is suitable for chemistry instruction

( ) high; ( ) medium; ( ) low

The game is well planned and demonstrates internal consistency

( ) high; ( ) medium; ( ) low

Overall I would rate this game's quality and usefulness as:

( ) high; ( ) medium; ( ) low

OTHER: _____

_____

COMMENTS: _____

_____

APPENDIX 3

ALBERTA HIGH SCHOOL OBJECTIVES

OBJECTIVES OF SECONDARY SCHOOL SCIENCE FOR ALBERTA

The learning of science as an area of human endeavour, should provide the student with a scientific literacy which enables him to assume an active and useful role as a citizen in a democratic society. It may be assumed that this literacy is best achieved by considering the individual needs of students and through independent study and learning.

The objectives of Secondary School Science are:

1. To promote an understanding of the role that science has had in the development of societies.

   a. history and philosophy of science as part of human history and philosophy

   b. interaction of science and technology

   c. effect of science on health, population growth and distribution, development of resources, communication and transportation, etc.

2. To promote an awareness of the humanistic implications of science:

   a. moral and ethical problems in the use and misuse of science

   b. science for leisure-time activities.

3. To develop a critical understanding of those current social problems which have a significant component in terms of their cause and/or their solution:

   a. depletion of natural resources

   b. pollution of water and air

   c. overpopulation

   d. improper use of chemicals

   e. science for the consumer.

4. To promote understanding of and development of skill in the methods used by scientists:

   a. processes in scientific inquiry such as observing, hypothesizing, classifying, experimenting and interpreting data

   b. intellectual abilities such as intuition, rational thinking, creativity, and critical thinking

   c. skills such as manipulation of materials, communication, solving problems in groups, and leadership.

5. To promote assimilation of scientific knowledge:

   a. emphasis on fundamental ideas

   b. relevance of scientific knowledge through inclusion of practical applications

   c. application of mathematics in science

   d. interrelationships between the sciences

   e. open-endedness of science and the tentativeness of scientific knowledge.

6. To develop attitudes, interests, values, appreciations, and adjustments similar to those exhibited by scientists at work.

7. To contribute to the development of vocational knowledge and skill:

   a. science as a vocation

   b. science as background to technical, professional and other vocations.

OBJECTIVES OF HIGH SCHOOL CHEMISTRY

In pursuit of scientific literacy, students in a chemistry program should strive to achieve the following objectives:

1. Develop skill in the methods used by chemists such as:

   1.1 processes in scientific inquiry: observing, hypothesizing, classifying, experimenting and interpreting data.

   1.2 skills in the cognitive, affective, and psycho-motor domains.

   1.3 skills in individual and group problem solving.

2. Acquire a working knowledge of:

   2.1 the fundamental ideas in chemistry

   2.2 the applications of the fundamental ideas

   2.3 the interrelationships among the different sciences and mathematics

   2.4 the tentativeness of chemical theory

3. Acquire a background knowledge about such issues as:

   3.1 use and depletion of natural resources

   3.2 chemistry of environmental pollution

   3.3 use and misuse of chemicals such as preservatives, additives, insecticides, etc.

4. Acquire a background of knowledge and experiences in the application of chemistry such as:

   4.1 chemistry in the home

   4.2 leisure-time activities such as photography, automotives, etc.

   4.3 consumer chemistry

   4.4 chemistry in industry

5. Develop an awareness and critical understanding for decision-making on value issues arising out of the use and misuse of chemistry.

6. Acquire a knowlege and appreciation of the history and philosophy of chemistry.

7. Develop a background of chemical knowledge and skills prerequisite to future careers.

APPENDIX 4

ALBERTA HIGH SCHOOL CHEMISTRY PROGRAM OUTLINES

PROGRAM OUTLINE

CHEMISTRY 10

CORE

About 40 hours

1. Basic skills of scientific experimentation.
2. Theoretical bases.
3. Language of Chemistry.

ELECTIVES

(1 or more to be chosen) About 25 hours

Metallurgy
Chemicals in the environment
Chemicals in the marketplace
Chemistry of Photography
Locally developed unit

CHEMISTRY 20

CORE

About 40 hours

4. Solutions.
5. Bonding.
6. Organic Chemistry.

ELECTIVES

(One or more to be chosen) About 25 hours

Polymers
Biochemistry
Environmental Chemistry I
Qualitative Analysis
Chemistry of the Car
Locally developed unit

CHEMISTRY 30

CORE

About 75 hours

7. Chemical Change.
8. Proton Chemistry.
9. Redox Reactions.

ELECTIVES

(Two or more to be chosen) About 45 hours

Rates of chemical reactions
Chemical equilibrium
Radiation chemistry
Organic chemistry
Environmental problems
Industrial chemistry and people
Food chemistry
Fossil fuels as energy or feedstock
Locally developed unit

APPENDIX 5

GAMES SUITABLE FOR CHEMISTRY TEACHING

GAMES SUITABLE FOR USE IN CHEMISTRY

GAMES FOR DRILL AND PRACTICE

Available from: R. L. Gang Teaching Aids Co.,
65 W Fayette Avenue
Salt Lake City, Utah, 84101

Chem Chex (1971)

R. L. Lang

Chem Cubes (1972)

R. L. Lang

Chem Bingo (1971)

R. L. Gang

* * * * *

Compounds

Nelson Payne

Playing Data: Copyright: 1974, Paul Ploutz
Age level: junior high and up
Playing Time: 30 minutes

Producer: Educational Games, Mary E. Hawkins,
Paul F. Ploutz,
c/o Union Printing Co.,
17 West Washington St.,
Athens, Ohio 45701

Elements

Paul F. Ploutz, Ohio University

Playing Data: Copyright: 1970
Age Level: grade 7--college science-method courses
Number of Players: 2 to 6
Playing Time: 20 to 60 minutes in periods of optional length
Preparation Time: none

Producer: Union Printing Co.,
17 W. Washington Street,
Athens, Ohio 45701

Ordering the Elements

Hugh Oliver and Doug Getty, Ontario Institute for Studies in Education

Playing Data: Copyright: 1971
Age Level: grades 9-12
Number of Players: 1 to any number
Playing Time: 1 to 4 hours in periods of 40 to 45 minutes
Preparation Time: 30 minutes to 1 hour

Producer: The Ontario Institute for Studies in Education
252 West Bloor Street
Toronto, Ontario

Lab Apparatus

Mary E. Hawkins, Paul F. Ploutz

Playing Data: Copyright: 1975
Age Level: 10 to adult
Number of Players: 2-6 best; up to 10 can play
Packaging: professionally designed box, cards, spinner

Producer: Union Printing Co., Inc.
17 W. Washington St.
Athens, Ohio 45601

Cheminoes

Dominoes. 11-13 ys. 1-6 people, 1/2 to 1 hour

Producer: Chemical Teaching Aids,
Letham, Ladybank, Fife KY7 7RN

A simple game which provides good (but not 3-D) practice in construction of formulae.

Chemopoly

Walker, Susan W., and P. Waler.

Board game. 13-15 years. 2-6 people, 1-1-1/2 hour

To be published in S.S.R.

Monopoly based game; calculate and complete gram-formula mass of compounds.

Chemsyn

G. Eglington and J. R. Maxwell. 1972

Card game. 17-19 years, 1-5 people

Producer: Heydon & Son Ltd.
Spectrum Ho.,
Alderson Cres.,
London NW4 3XX

Well produced cards for group play or for self-testing and revision. Place cards in their reaction sequence.

Berzelius Bingo

S. Anne Spurr. March 1970

Lotto game. 12-15 years. 2-30 people, 1/4 - 1 hour

Producer: S.S.R., 1970, 176, 51, 680-1

A tested game of chemical lotto. Match names of elements to symbols.

Longman Science Games

Playing Data: Age Level: grades 7-12

Producer: Science Games,
Longman Group Ltd.,
Resources Unit,
35 Tanner Row,
York, England

Classification: The objective of this competitive game is to understand the basic concepts of classification. The game involves the ordering of animate and inanimate materials and leads to a good understanding of the classification process. Suitable for all elementary General Science courses.

Science Sense: The game emphasizes safety in the laboratory Players are made aware of the many hazards found in a science laboratory and the need to take precautions. This Unit is particularly suitable for all pupils embarking on science courses.

Chemical Families: This Unit includes two competitive games on the classification of the elements. Players build up groups or families of elements of the periodic table. The purpose of the Unit is to give an understanding of the periodic table and includes some historical knowledge of its development. Useful in all Chemistry courses.

Atomic Structure and Bonding: This is a competitive game in which the players first build up the Atomic Structures of certain atoms and then go on to use these to interpret the bonding in simple molecules and ionic compounds.

Chemistry's Alphabet: A competitive circuit game based on the names, formulae and properties of some common elements and their properties. This Unit is aimed at the middle school pupil beginning a course in Chemistry.

Competition Amongst the Metals: A game devised to study the simple properties and reactions of metals. Based on the reactivity series of metals, the game involves occurrence, extraction, reactions, displacement, corrosion, etc.

Element & Compound

Game. 13-15 y.

Producer: Science Education Games
5 Heathfield Road
Hasbury, Haleowen,
Wores, B63 1AD

Revision of the properties of elements and compounds

Element Cards

J. Lipson

Card games. 13-22 y.

Producer: Heydon & Son

Each element card has a multitude of numbers for use in [illegible]ne possible games. Any chemistry learnt might be incidental to the games

Wff a Mole

Alma P. Armstrong. June 1973

Dice game. 12-19 y., 204 players. 10 x 1/4 h.

Producer: S.S.R., 1973, 189, 54, 751-7
Sagset News, October 1974, 4,84-98.

Order dice to make chemical statements

Ionics

Card game. 13-15 y. 2-5 people. 1/4 - 1/2 h.

Producer: Science Systems,
173 Southampton Way
London, SE5 7EJ

Combine cards to make ionic formulae or equations which can be challenged. Quick and simple to learn.

Formplax

Card game. 12-16 y.

Producer: Chemical Teaching Aids.

Illustrates chemical formulae and the balancing of equations.

Formulon

J. S. Stoane, 1971

Card game. 13-16 y. 1-8 people, 1/4 h.

Producer: Chemical Teaching Aids

'Rummy' formula construction game with 100 cards is simple and straight-forward, but the teacher may need to check for correct solutions.

Mole Bingo

Alma P. Armstrong, 1973

Lotto game. 13-19 y. 2-5 people

Producer: S.S.R., 1973, 189, 54, 751-7
Sagset News, Oct. 1974, 4, 84-98.

Simple calculations with chemical numbers allow looto card to be filled.

Organocards

D. Kristol and H. D. Perlmutter, 1971

Card games

Producer: Educ. in Chem., 1971, 8, 145 and 176

Two chemical card games.

P. & S. Properties & Substance

Alma Armstrong

Card game. 13-15 y. 2-8 people, 1/2 h.

Producer: Chemical Teaching Aids

Match up property with substance cards. Useful for revision; may need teacher assistance.

Precipitate

Payne (1970)

A chemical card game.

Source Unknown

* * * * *

GAMES FOR PROCESS SKILL DEVELOPMENT

In-Quest

Robert W. Allen, Leo E. Klopfer and R. Lawrence Liss.

Playing Data: Copyright: 1970
Age Level: grades 7-12
Number of Players: 2 to 4
Playing Time: 2 to 8 hours in 50 minute periods
Preparation Time: 20 minutes

Producer: Wff 'N Proof,
1490 South Boulevard,
Ann Arbor, Mich.
48194

Explanation

Charles H. Adair and Rodney F. Allen

Playing Data: Age Level: grade 8 - graduate school
Prerequisite skills: 8th grade reading
Number of Players: 6
Preparation Time: None

Producer: Described in book only: Teacher Research: Simulation Exercises and Games,
CAI Center, Florida State University,
Tallahassee, Florida 32306

Hypothesis Machine

Frank Micciche

Educational Materials and Equipment Co.,
Box 63
Bronxville, New York 10608

Thé Amsyn Problem

Role playing game; uses hypothetical situation in chemical industry to develop skills in problem solving, hypothesizing, gathering information, evaluating information, decision making. Attitude development, such as limitation of science to deal with social problems; empathy.

Dr. F. Percival,
Educational Technology Unit,
RGIT, St. Andrew Street
Aberdeen Scotland, AB1 1HG

Queries 'n Theories

Layman E. Allen, University of Michigan; Peter Kugel, MIT;
Joan Ross, University of Michigan

Playing Data: Copyright: 1970
Age Level: grade 7-graduate school
Prerequisite skills: reading, grade 7; math, grade 9 (with extensive teacher assistance)
Number of Players: 2 to 4

Producer: Wff 'N Proof,
1490 South Boulevard,
Ann Arbor, Mich. 48104

Science Education

H. Romesburg.

"Simulating Scientific Inquiry with the Card Game Eleusis," 63: 599-608; 1979.

Xtal-Line

Allsobrook, Brown and Glasser
found in Journal of Chemical Education: pp. 688-689, October, 1973.

A board game in crystallography.

GAMES FOR ATTITUDE DEVELOPMENT

The Amsyn Problem (described above)

The Pollution Game (1971)

F. A. Rasmussen

Deals with the problems of industrial pollution; role play.

The Planet Management Game (1971)

V. M. Showalter

Deals with allocating limited resources and their management.

Both of the above available from: Houghton Mifflin Co.,
110 Trenton Street,
Boston, Mass., 02107

Keeping Warm

A game devised to draw attention to the necessity for energy conservation. Pupils are first made aware of the ways in which heat is lost from a home and how it can be conserved. The game develops to illustrate the economics of heating a home in an age of dwindling energy resources. A Longmans Group game (see address above).

Chemical Manufacturing (1972)

D. E. Wilson

Role Play. 15-19 y.

In: Taylor and Walford, Simulation in the Classroom

The interactions of economics and chemical feasibility.

Energy Management Game

Developed by BSCS
Board and Role

Players must operate power plants and make decisions which could affect the environment and community.

Producer: Hubbard,
Box 104,
Northbrook, Illinois, 60062.

SOURCES FOR ORIGINAL SCIENTIFIC PAPERS

Conant, James. Harvard Case Studies in Experimental Science, Volumes One and Two. Cambridge, Mass.: Harvard University Press, 1957.

Dampier, and Dampier. Readings in the Literature of Science. New York: Harper and Brothers, 1959.

Jones, H., and Cohen, I. B. A Treasury of Scientific Prose. Boston: Little, Brown and Co., 1963.

Moultin, F., and Schifferes, J. The Autobiography of Science. New York: Doubleday and Company, 1960.

Schwartz, G., and Bishop, P. Moments of Discovery, Volumes One and Two. New York: Basic Books, 1958.

APPENDIX 6

A SUGGESTED ABRIDGED GAMES ASSESSMENT INSTRUMENT

A SUGGESTED ABRIDGED GAMES ASSESSMENT INSTRUMENT FOR TEACHER USE

1. TITLE: _____

2. MEDIUM: ( ) game board ( ) cards ( ) booklets
( ) paper and pencil ( ) role play
( ) other manipulatives: _____

3. FORMAT: ( ) individual play ( ) group play
( ) role play ( ) competition
( ) other _____

4. Number of players: _____

5. Time required for adequate play: _____

6. Central Problem for the game: _____
Related to: ( ) core unit: _____
( ) elective unit: _____
( ) supplementary or enrichment _____

7. Intended users: age or grade level: _____

8. Difficulty level: ( ) intellectually challenging
( ) involves chance more than skill
( ) has a high level of inquiry
( ) drills content
( ) other _____

9. Learning outcomes: ( ) practice content
( ) develop process skills
( ) develop attitudes
( ) develop psychomotor skills
( ) other _____

10. Rules: ( ) clear, easily understood

( ) congruent with central problem

11. Game activities: ( ) are plausible within the context of the game and reality.

( ) allow all players to participate actively

( ) summary activities relate game to real life

( ) summary activities mirror the results of the game

12. COMMENTS: _____

_____

_____

_____

13. Overall I would rate the game's quality and usefulness as:

( ) high ( ) medium ( ) low