Using group investigation for chemistry in teacher education

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Abstract

In the context of Group Investigation in e-learning environment, learning to work together productively as well as to interact socially and effectively in a group is a difficult task. A variety of skills, for example, interpersonal, problem solving, and study skills would be needed. It is also not uncommon to assume that learners would have acquired these skills and the processes of group work from their experiences on social interactions and discourse. Therefore, modeling of Group Investigation is one way to address this problem. This paper provides insights on using constructivist paradigm for instructional design that maximises the potential of Group Investigation to enhance e-learning. An on-line module on computer-based learning in chemistry is selected for illustration. Implications for design in science and technology education program and the data derived from the study of modeling process will be discussed.

Introduction

The vast research literature on the impact of cooperative learning on student success seems to dictate the importance of this classroom structure for classroom teaching and learning (Davidson & Worsham, 1992; Sharan, 1994). When properly conducted, cooperative learning, a group and student-centered instructional approach will promote problem-solving skills, social skills and thinking skills of the learner than both individualised and competitive efforts (Johnson & Johnson, 1991). However, in an e-learning environment which usually involves collaborative learning, it seems that educators or pre-service teachers often assume that learners or students would have learnt these skills as well as the processes of group work from their own experiences on social interactions and discourse. Studies have found that modeling of Group Investigation can bring about cooperative learning as well as thinking skills during the learning process (Tsoi, Goh & Chia, 2000, 2001). As such, modeling of Group Investigation is one way to address this teaching/ learning situation.

Basically, Group Investigation involves the integration of four essential features: investigation, interaction, interpretation, and intrinsic motivation (Sharan & Sharan, 1992). It provides a social context for learning. To understand the goals and procedures of this model of cooperative learning, it would be appropriate then to be aware of the types of cooperative learning. There are formal cooperative learning, informal cooperative learning, cooperative base groups, and cooperative structures (Johnson, Johnson & Holubec, 1992). In this paper, we are concerned with formal cooperative learning in chemistry where the pre-service chemistry teachers of the PGDE (S), Postgraduate Diploma in Education (Secondary), program are to achieve shared learning goals and complete specific tasks and assignments together. They work together for one class period for several weeks.

Figure 1 illustrates the use of formal cooperative learning. In formal cooperative learning groups, educators or teachers would need to (a) specify instructional objectives for the lesson or activity; (b) make preinstructional decisions such as the size of the group, the way of forming groups, the assigned roles, and the resources needed; (c) explain task and cooperation where positive interdependence and individual accountability are emphasised as well as the criteria for success given and the social skills expected; (d) monitor and facilitate the process of cooperative learning where assistance would be provided to help students to complete the task accurately and work together effectively; (e) evaluate student's learning and assist the group to process how effective the group has functioned.

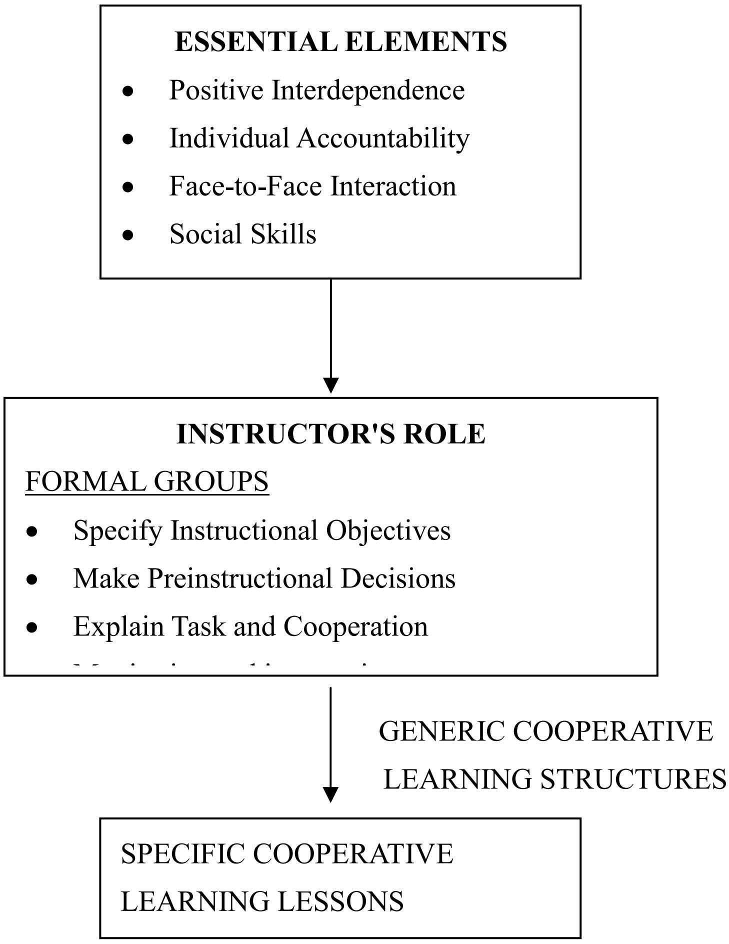

Figure 1. Cooperative Learning

Instructional design

Group Investigation has a strong foundation in John Dewey's philosophy of education where he believed that the students would have experienced meaningful learning if they have been exposed to the stages of scientific inquiry. So, this would help students "learn how to learn" (Sharan & Sharan, 1992). However, it is equally important to create a cooperative learning environment that involves interaction among students,

interpretation of information and findings as well as intrinsic motivation where students are motivated to take an active role in determining what and how they will learn so that Group Investigation can then be effective.
With this in mind, an instructional design based on constructivist paradigm is then developed focussing on modeling of Group Investigation to the pre-service chemistry teachers of the PGDE (S) program. This program is a one year full time course of study to prepare chemistry teachers to teach in secondary schools. Group Investigation seems compatible with the constructivist paradigm in that it establishes a situation in which students interact with an information rich environment while working collaboratively with others in a cooperative climate to investigate a problem, plan and make presentations, and evaluate their projects.

As such, certain aspects of ISD (Instructional Systems Design) would have to become more flexible when a constructivist paradigm is adopted (Bednar et al., 1995). In this context of modeling of Group Investigation to pre-service chemistry teachers, content analysis is not important because content cannot be prespecified. Domains can be defined, but specific objectives must come from the pre-service teachers' perception of relevancy. In other words, the generic ISD model also known as the AADIE Model that involves an integrated set of steps (analysis, design, development, implementation, and evaluation) evolved from general systems theory would have to be adapted to this paradigm. This would mean that sometimes steps could be done concurrently or incompletely. Development of multiple perspectives on a task should be encouraged. As the focus is on the learner's level of reflectivity and individuality, an analysis of representative learners is not necessary.

The evaluation aspect needs to be modified accordingly because traditional ISD sets standards for success through predetermined objectives. Although the constructivist paradigm does allow for evidence of outcomes, it is often primarily subjective evidence. Nonetheless, constructivism seems appropriate for developing Group Investigation. This would then call for a responsive environment that provides for the active, self-regulating, reflective learner who would be motivated intrinsically to pursue the learning goals. Evaluation should also be goal-free and examine the learning processes, for example, the way knowledge is constructed, and the desired outcomes achieved or final product derived meaningfully. Indeed, constructivism has many roots in social psychology and other social learning paradigms. Table 1 illustrates the constructivist paradigm for instructional design focussing on Group

Investigation.

Instructional Problem: To learn about computer-based learning in chemistry	
	Constructivist Paradigm
Goals	Each learner specifies what their individual goal is in relation to the topic
Assessment	Instructor, peer and self evaluation through group sharing, checklist, assignments such as lesson planning task
Strategies	Modeling, exploration, collaboratively investigating, interacting, and interpreting with intrinsic motivation (Group Investigation with appropriate and relevant cooperative learning structures such as roundtable, roundrobin, jigsaw)
Delivery Systems	An information technology cooperative learning environment providing rich, relevant and interesting information and resources on computer-based learning in chemistry

Table 1. Constructivist paradigm for instructional design

Basically, the modeling of Group Investigation to pre-service chemistry teachers involves the following six stages:

Stage 1: Class determines subtopics and organises into interest groups. (Encourage group members to generate questions for investigation that interest them)

Stage 2: Groups plan the investigations. (Assist group members to make realistic plans in which they choose the questions to be answered, determine the resources required, divide the work and assign roles)

Stage 3: Groups carry out the plan. (Group members locate information, organise and record data, report findings to the group, discuss and analyse the findings, determine whether more information is required, and finally, interpret and integrate their findings)

Stage 4: Groups plan the presentations. (Help and mentor group to identify the main ideas of the findings)

Stage 5: Groups make the presentations. (Lead the class in determining criteria for the evaluation of the presentations and in providing feedback)

Stage 6: Instructor and pre-service teachers evaluate their projects. (Facilitate the integration of their findings and conclusions as well as the learning process)

The modeling process as described is applied to an on-line pre-service module on computer-based learning in chemistry at secondary level that involves the "what", "why", and "how" aspects of this learning technology. The course is designed to (a) provide a pedagogical framework for the use of IT-based teaching/learning materials in chemistry at secondary level, (b) introduce selected IT-based learning software, tools and internet resources for teaching and learning in chemistry at secondary level, (c) provide guidelines for the evaluation of IT-based resources, and (d) raise an awareness of the practical issues and concerns in the use of IT-based resources in the teaching and learning of chemistry at secondary level. At this juncture, it seems appropriate to describe briefly the pedagogical and knowledge dimensions of the module with reference to a classification scheme on the taxonomy of web-based learning environment developed by Mioduser et al. (2000). The pedagogical dimension consists of a number of instructional and learning variables that are concerned with the type of instruction elicited. The instructional configuration and model are that of an inquiry-based classroom collaborative learning via the instructional means of information base and open-ended activity. The interaction type is browsing and simple activity. The cognitive process is information retrieval, information analysis and inferencing as well as problem solving and decision making. The locus of control is that of student controlled and the learning resources are linked web resources as well as additional external resources. As for evaluation, it emphasises alternative modes of evaluation.

In this cooperative e-learning environment for chemistry in which Group Investigation is infused and modeled, the primary goal is to investigate a theme selected from the course website taking into account the conceptual framework of the curriculum, the principles of lesson plan and preparation, as well as the various instructional approaches appropriate for the teaching of chemistry at secondary level. The five themes are IT-based learning in chemistry; IT-based learning software and tools; Internet and chemistry; evaluation of IT-based resources; and practical issues and concerns in using IT in education. This instructional task is relevant and authentic as it also deals with meaningful connections of both procedural and declarative knowledge on using IT (Information Technology) in the classroom context of teaching and learning chemistry at secondary level. This would allow specific objectives to emerge that are relevant to the learner. The learning sequence would not be controlled and multiple perspectives would also be provided. As such, a variety of appropriate and relevant resources is provided to complement the online module. For example, library resources such as books, journals and magazines on chemistry, chemical education and information technology, textbooks and activity books that focus on key concepts and development of subject topics, CD-ROMs on chemistry, as well as Internet resource materials are provided.

The various stages of Group Investigation are then modeled with the applications of cooperative learning structures, Roundrobin, Roundtable and Jigsaw. In Stage 1, Roundrobin is used for teambuilding in which there is expression of ideas and opinions as well as equal participation leading to acquaintance among group members. After which, Roundtable is used for information exchange within the team where each learner in turn writes one short answer as a paper and pencil are passed around the group. These two cooperative structures call for equal participation and team building. Jigsaw is most appropriate and useful as we are dealing with division of labour in Stage 2 in which work is divided and roles are assigned amidst the selection of both the questions to be answered and the resources required. However, the Jigsaw strategy is further modified in a reverse mode, that is from the original home group where the members are expert in one of the 5 themes to new home group and then back to the original home group, so as to accommodate Stage 5 in which members from the expert groups of themes 1 to 5 rearrange to form the so-called new home groups that comprise different members from the expert group and the themes 1 to 5 are then presented and shared among the new home group. After which, the members return to their original home group to further discuss on the sharing of the 5 themes.

The following gives an account of the relevant questions and responses selected among the investigations of the five themes:

How can we integrate IT into our lessons? For example, using CDROMs to introduce abstract ideas such as mole concept; having virtual lessons such as on-line discussion, on-line tutorial, on-line assessment; applying cooperative learning such as using IT to do group work; and using Microsoft-office products such as graph-plotting, excel calculations and word processing (IT-based learning in chemistry).

How do you select the software and tools? For example, using certain criteria to select or evaluate; locating the source of the software; knowing and classifying the different types of software and tools such as drill & practice, tutorial, games, edutainment, simulations, electronic textbook, Microsoft-office products (IT-based learning software and tools).

What are the characteristics of a good chemistry website and how to adapt the website for effective classroom teaching? For example, applying certain guidelines to select a good website; developing collaborative projects; integrating the Internet into the classroom teaching and learning activities via strategies such as Web quest, Group investigation, treasure hunt and java applets (Internet and chemistry).

What are the different ways of evaluating IT resources and how to reduce the time spent in locating suitable resources? For example, using a simple guideline or criteria to evaluate the IT resources; making use of the ministry of education IT website, the Edumall to locate appropriate and relevant IT resources such as the Internet, CDROMs, and lesson plans (Evaluation of IT-based resources).

Where do we get the relevant resources, how do we manage the students in the IT environment and what are the problems faced in using IT in education? For example, reviewing and searching the provided on-line course website for chemistry teaching resources; applying cooperative learning strategies and Group Investigation method; use IT pedagogically and in one step at a time; and applying the classroom management skills taught during lectures and tutorials (Practical issues and concerns in using IT in education).

Table 2 shows the learning process checklist (Sharan & Sharan, 1992) that could be used appropriately between Stage 4 and Stage 6 so that group members are more aware of the processes that have taken place and how best to improve the group dynamics and content of the Group Investigation. The quantitative data collected from 78 pre-service teachers for secondary level is also shown in Table 2. Due to time constraint, there could not be making and evaluation of the projects for stage 5 and 6. Nevertheless, in terms of the learning process outcomes of Stage 1 to Stage 4, there are positive responses. Indeed, there is sharing of ideas, opinions and materials, helping of one another, planning, interpreting, and interacting purposefully in the instructional tasks.

Table 2. Learning Process Checklist Results

	SA	A	DA	SDA
Stage 1: Groups Determine Subtopics				
Was there:				
Exploring of options?	41	37		
Connecting personal knowledge to the problem?	37	41		
Generating of questions?	43	35		
Sorting of questions?	42	36		
Determining of subtopics?	43	35		
Choosing subtopic for investigation?	45	33		
Stage 2: Groups Plan Their Investigations	SA	A	DA	SDA
Was there generating of questions?	47	31		
Did you clarify thoughts with groupmates?	41	37		
Did you anticipate what they will study?	17	43	15	
Did group choose relevant sources?	44	34		
Did group decide what to investigate?	59	19		
Were roles assigned?	62	16		
Stage 3: Groups Carry Out Their Investigations	SA	A	DA	SDA
Was there:				
Locating information from a variety of sources?	50	28		
Comparing and evaluating relevance of sources?	46	32		
Explaining, expanding and refining knowledge and generalising information?	46	32		
Formulating answers to questions?	42	36		
Stage 4: Groups Plan Their Presentations	SA	A	DA	SDA
Was there:				
Identifying main idea of findings?	37	41		
Explaining, comparing, evaluating findings?	40	38		
Connecting findings to the general problem?	36	42		
Deciding how to present findings?	26	52		

Stage 5: Groups Make Their Presentations	SA	A	DA	SDA
Was there:				
Demonstrating meaningful use of knowledge?				
Evaluating the clarity, appeal and relevance of other presentations?				
Making new connections between subtopics?				
Stage 6: Teacher and Students Evaluate Their Projects	SA	A	DA	SDA
Was there:				
Evaluating main ideas of outcome of inquiry?				
Evaluating factual knowledge?				
Integrating all groups' findings?				
Reflecting on performance as investigators and as group members?				

SA: Strongly agree A: Agree DA: Disagree SDA: Strongly disagree

Conclusions

Theories of learning with much influence by cognitive science movement have in a way affected instructional design. However, there is now interest in building instruction to facilitate not only the thinking processes but also the social interaction processes. As such, a constructivist paradigm for instructional design may be appropriate for modeling of Group Investigation to pre-service teachers. This paradigm claims that learning is more than conditioning or acquired knowledge, rather it is constructed knowledge. This means that learners interpret information in the context of their own experiences. Learning should be personalised, set in authentic contexts, and oriented to problem solving. In other words, learning should allow learners to assume roles and interact with others, present problems to be solved, emphasise intrinsic awards, embed in a realistic and practical setting, involve the learner in goal setting and encourage multiple perspectives.

In this case, the constructivist paradigm for the instructional design would comprise:

(a) learning is personal discovery based on insight; (b) type of learning is problem solving; (c) instructional strategies are provided for active, cooperative and reflective learner; (d) media strategy is a responsive and cooperative learning environment; and (e) the key concept is autotelic principle (intrinsic motivation). Indeed, modeling of Group Investigation would address this learning situation to a good extent.

For effective modeling of Group Investigation, the instructor needs to understand the nature and essential components of cooperative learning. Besides, the instructor needs also to assess the learners' ability to plan and study together, choose the relevant authentic problem for Group Investigation, think through possible questions about the problem, and locate a variety of resources. Social skills, for example, communication, conflict-management, decision-making, leadership, and trust-building need to be taught for effective group processing. The meanings of positive interdependence, individual accountability, social skills, and group processing as well as problem solving heuristics need to be fully understood so that Group Investigation could be modeled effectively.

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