

Problem-solving in a Constructivist Environment

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ABSTRACT

The dynamic challenges of an increasingly borderless world buoyed by advances in telecommunications and information technology has resulted in educational reform and subsequently, a reconceptualisation of what constitutes a learner, learning and the influence of the learning environment on the process of learning. In keeping up with the changing trends and challenges of an increasingly networked, dynamic and challenging international community, means to provide an alternative environment that stimulates inquiry and equips learners with the skills needed to manage technological change and innovations must be considered.

This paper discusses the importance of interaction, cognition and context, collaboration in a networked computer-mediated environment, the problem-solving approach as a catalyst in stimulating creative and critical thinking and in providing context for meaningful interaction and whether the interactive environment created through computer-mediated collaboration will motivate learners to be responsible for their own learning and be independent thinkers.

The sample involved learners from three schools in three different countries. Findings conclude that a rich interactive environment must be personally relevant to the learner by simulating authentic problems without lowering the degree of cognitive complexity. Review in curriculum, assessment and teacher training around constructivist principles are also imperative as these interrelated factors form part of the learning process system.

Keywords

Interactive, Constructivist, Computer-mediated communication, Problem-solving, Process of learning

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Introduction

In view of today's Information Age, skills to resource information intelligently and make meaning out of this plethora of information has become increasingly important. Education too must keep in sync with the trends in our dynamically changing world by creating creative individuals capable of communicating, collaborating with others and able to solve problems independently and effectively.

Interaction, cognition and context

Constructivism asserts that comprehension or learning is in relation to our interactions with the environment; be it the learning content, peers or teachers. Since rapid change requires adaptability, flexibility, problem-solving skills and innovation, the value of self-initiated exploration of resources that draws the learner into active participation with the learning content, activities and environment must be recognised. If we continue to focus merely on the delivery of information and regard students as passive learners, cognitive growth will be retarded as thinking about what to learn and learning how to learn become primarily the responsibility of the teacher. Thus, a "minimalist" learning environment must be replaced with a "richer" environment that encourages interaction between the learner and the learning environment (Wilson, 1995).

The importance of interaction with the environment is further highlighted by the necessity for "cognitive conflict or puzzlement" which provides a reason and incentive for the students to inquire and explore the resources surrounding them. Accurate formulation of goals to solve this cognitive conflict is therefore essential as these goals will enable the learner to be more focused in order to determine the scope and relevance of new information (Duffy & Jonassen, 1992).

Asserting that students are not merely “knowers” but “learners”, Laszlo and Castro (1995) reiterate that students should not be expected to merely store information in their minds. Instead, they should be encouraged to use their minds to process the information meaningfully. Otherwise, there will be little motivation to relate the current information put forth to them with other prior concepts or to apply this information to situations that do not pertain to their assignments or examinations.

This in turn will result in incongruity between the world they study in and the real world. Berliner (1992) points out that actual real-world tasks necessitate enquiries to answers, which are not predetermined. As such, students should be encouraged to explore and experiment means to form significant knowledge and means to enhance what they already know in relation to their real world. They should not merely experiment with learning sequences or learning outcomes that are already predetermined.

In addition, (Zimmerman, 1989) claims that they should assume responsibility for their own learning and take measures to achieve its success. Empowering students however needs to be complemented by effective self-regulation. Students must be able to plan and set their own goals, reflect and assess their progress as well as determine how to proceed. This subsequently necessitates tasks that are interesting in order to “foster, nurture and trigger” meaningful and relevant inquiry as they assimilate and accommodate new information against the existing mental model in attempts to reach resolution of cognitive conflict.

Therefore, activities or projects that simulate the real world in terms of depth and complexity are desirable to enhance the quality of learning experience and subsequently enhance the development of a wider range of abilities. Once learning is engaging, they will be absorbed in their environment and be more attentive, imaginative and motivated to explore further.

This reorientation towards a learner-centred paradigm reflects on the principles espoused by APA’s Learner-Centred Psychological Principles (1993) that redefine our notion of the learner, learning and the learning environment. Students are viewed holistically as people with intellect, emotions and social capabilities. Hence, learning is influenced by the learners’ cognitive and emotional interpretation of situations as they interact with their environment in their attempts to achieve their learning goals. Since understanding is dynamic with iterative hypotheses testing, assimilation and accommodation of information against existing knowledge, the ability to resource appropriate input from the learning environment and the richness of the environment itself are vital to the success or failure of learning (Wagner & McCombs, 1995).

With this in mind, technology has been proposed as a mediator for creating engaging, fun and meaningful interaction that enables learning to be supported and fostered. An example of this facilitative technology is computer-mediated communication.

Computer-mediated communication

Besides enriching the content of discussion and the quality of the eventual product, CMC enables students to negotiate meaning and construct knowledge in a situational context that enhances meaningful collaboration through collaborative problem solving.

Since learning is enhanced by interacting with others and surrounding resources, Duffy and Jonassen (1992) surmise that the process of confirming our comprehension in collaborative groups will provide a means to enhance and broaden the students’ perspectives and facilitate resolution of their cognitive conflict. Due to the diversity inherent in collaborative heterogeneous groups, students will seek to clarify, explain and justify their stand. This encourages the creation of content and context-related construction of knowledge rather than mere reproduction of knowledge. Hence, Vanderbilt (1996) notes that the web of concepts and ideas spun by the relation of facts and ideas encourages thoughtful learning and subsequently, increases understanding.

Harasim (1989) agrees to a more interactive approach that encourages active dialogue. She rationalises that students are exposed to multiple perspectives that serve to form cognitive scaffolds as the students resource information from each other, the people around them and the experts in the field. Furthermore, through collaboration students are encouraged to question and solve problems that they encounter by themselves. As each person’s idea is contributory to achieving their common goal, collaboration gives value to their voice and helps them to form their own stand. With an actual audience, there is someone who really listens and considers

their ideas. Therefore, they begin to realise the importance of their own ideas and the significance of presenting this voice clearly.

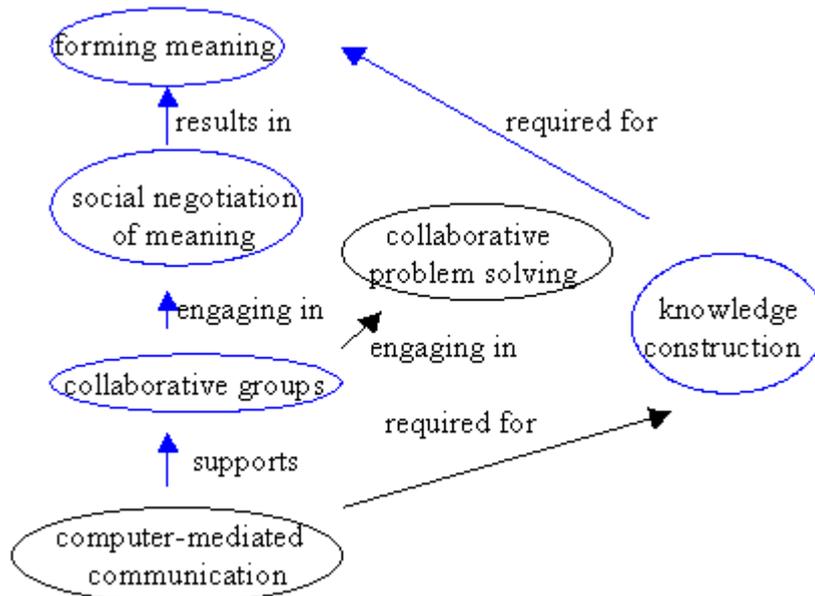


Figure 1. Computer-mediated communication as a facilitative tool for collaborative group work (Jonassen, 1996: 148)

Thus, Fulton (1996) believes that networked collaborative classrooms enable assignments to become windows and assignments that entice students to go deeper and deeper into their own understanding of the subject matter provide windows to glimpse questions and contradictions that demand their attention. There is a shift in focus from external accumulation of information to internal experience of making meaning (p.2).

As such, having ample opportunities for exploration via multiple activities in various contexts will enrich instruction and open avenues for interaction with others as well as with their learning context. Being interested in the task at hand, students will initiate as well as formulate the means to achieve their learning goals. As meaningful interaction takes place, they are likely to be absorbed in their learning environment and be intrinsically motivated to learn. Provision for collaborative learning to enable students to learn from each other as they contemplate means to search for resources further increases the value of the thinking process, which no longer occurs in isolation but is facilitated by multiple responses. Learning is thus fostered and supported (Laszlo & Castro, 1995).

The problem-solving approach

As indicated by Zimmerman (1989), any form of learning should be personally relevant to the learner. A means to provide personal relevance is by simulating authentic problems without lowering the degree of cognitive complexity. Since these problems are similar to the challenges the students will face in their real world, tasks which require problem-solving becomes more engaging, as the students want to know what the possible outcome may be. As such, they will be more willing to explore all possible relevant perspectives. In other words, the students will perceive learning as purposive and not view the task as merely an assignment to be undertaken (Savery & Duffy, 1995).

In addition, similar to authentic environments, the students should also be encouraged to figure out the process for meeting their learning goals. The problem-solving process indicates that the students are no longer told what or how to study. On the contrary, they are encouraged to decide these for and by themselves. The learners are challenged to think. In other words, thinking is not “proceduralised or dictated upon”.

This however, does not minimise the role of the teacher. As the facilitator, he must value the learners’ thoughts and prompt them to inquire further with questions such as “Why?” and “What does this mean?” Moreover, the teacher should encourage the learner to confirm their hypotheses by testing them against other students’ ideas.

Hence, the teacher prompts them to approach the problem from various perspectives and contexts thus enriching the learners' comprehension and encouraging them to reflect and regulate their own learning (Wilson, 1995).

In view of the benefits of an interactive approach to learning, some Malaysian students were given the task of creating a web-site together with two other schools, each in a different country, for the 1997 AT & T Virtual Classroom Contest. In line with Barrows' (1992) problem-solving based learning principles, the students were not told what information to look for nor how they should go about creating the web site in collaboration with the other two schools via electronic mail.

They identified their own objectives, determined what to create, and what information they needed, sought advice from teachers, peers and relevant parties, gathered appropriate information, evaluated their resources and reflected on their collaboration. The students were not thrown into a situation totally unguided but were encouraged to resource information and determine means to solve the problem posed to them. As they were empowered and the task was interesting, it was hoped that they would become proactive and learning would become fun and engaging.

The AT & T virtual classroom contest

The AT & T Virtual Classroom contest aims to provide primary and secondary school students the opportunity and experience of collaborating on a world-wide basis using the Internet. Since global collaboration will have an increasing role in the future students should be given the opportunity to experience first hand the potential and drawbacks of international collaborative activities.

Each competing team consisted of three schools from different countries which will work together to create a web site. A schedule of activities was given to help them plan when they should complete the self-introduction stage, the planning stage, the web site creation stage and the reflection stage. The web site was assessed based on the extent the content appeals to an international audience, the quality of the web design and the extent of collaboration among the three schools. The ultimate goal of the contest however, is not so much the final product, but the collaborative process that makes the product possible.

The sample

For this case study, the three participating schools were a junior high school in France, a junior high school in the United States of America and a high school in Malaysia. Communication among them was purely via e-mail. These schools were paired based on the theme that they proposed i.e. water pollution. This report is based on the Malaysian experience.

Findings

During the brainstorming/pre-writing process

Identifying objectives. The Malaysian students determined that they had to identify the nature of their web-site i.e. either an on-line magazine, a newsletter, a scientific analysis of the current water pollution problem in their respective countries or something more interesting. After they had done this, they sent e-mail to their French and American counterparts and attempted to arrive at a consensus either to integrate all the suggestions proposed or choose only certain suggestions to be developed on, or figure out some other alternatives.

Other information that they needed depended on the result of discussions among the three schools. They were prepared to do research outside school hours to provide more depth to the information that they were going to present. Time also had to be allocated for trouble-shooting, as it was the Malaysian and French students' first experience in web page design. Instructors from a nearby university were identified as possible resources to assist in this matter.

Identifying the nature or form of the presentation. The students were initially interested in creating an on-line magazine. They wanted to create a fable and insert some riddles, poetry, a compilation of quotable quotes or original puns, rap songs or role-playing games.

Fables would provide avenues for presenting morals but there were already other web sites which presented this well. Riddles, poetry, puns and rap songs were considered unsuitable as the potpourri of these features might not be sufficient to attract an international readership, some of whom are ardent Web surfers used to viewing these forms of presentation.

Therefore, they decided on a role-playing game. The primary consideration was that role-playing games would provide for interaction between the content and the player as he is posed with options at different stages of the game, which would lead him to different paths and different consequences. As the player participates actively, he or she is more likely to be motivated to explore further as each step leads him or her to further meaningful information that will help him or her to accomplish his or her mission.

Incorporating hypertext in the Web pages facilitated the linking of web pages. The element of uncertainty and suspense were enhanced, as the reader could not flip through the pages at the back as in a traditional book to look at the answer before deciding on his/her option. He or she had to read the text on each Web page carefully, attempt to elicit clues, assess the information and decide on the best choice. Although the paths were pre-determined to a certain extent by its logical links, the interactivity between the player and the story provided an inherent challenge to the reader that was likely to motivate him to explore further while learning more about water pollution. Similar to a game, there was a reward or a punishment as closure.

In his study of what makes computer games so popular, Malone (1984) finds that computer game players are intrinsically motivated to play on due to the elements of challenge, fantasy and curiosity. Players tend to be drawn into the game, as outcomes are unpredictable through variations in the level of difficulty. Furthermore, multiple-levelled objectives as well as secretly hidden information can be provided for to increase the sense of challenge and curiosity.

In addition, fantasy influences the player emotionally and cognitively. Intrinsic fantasies can be in the form of gaining a reward, or having a wish fulfilled such as winning the game. Therefore, if adequate variation and levels of difficulty are successful in captivating the player, the player is more likely to be curious to know more as he/she perceives his/her present knowledge as insufficient to help him/her obtain his/her goals. Malone adds that other elements to be considered are the provision of choice, novelty and the element of surprise or incongruity with what the player will normally expect.

Creating a game has the potential to stir the player's curiosity, stimulate his/her fantasy of winning and challenge him/her to figure out what his/her next move should be based on the information he has. Thus, the students' decision to create a role-playing game instead of the on-line magazine appears to augur well with their primary concern that the reader should be curious and interested to explore further.

During the writing process: interacting with resources

Plot considerations. Similar to traditional story writing, plot, characters, setting and theme were considered. A common scenario was agreed upon. The plot revolved around a time traveller whose present (our future) was very polluted. Thus, he was given a mission to study how water pollution came about, reduce it and if possible, eliminate it. He could begin either from France, Malaysia or America.

In the Malaysian role-playing game, the main character was a mutant summoned by an intelligence agency to find the cause of water pollution, reduce it and if possible, eliminate the problem. If he succeeded, he would return as a hero. However, if he failed, not only would Earth be doomed, he would also be stranded in space forever.

The American version cast a secret agent as the protagonist assigned to stop a mad scientist from polluting Earth's water supply. A thriller, the plot provided interesting mid-air hijacks, a life-threatening struggle with a bear with humorous consequences, a possible mountain crash, FBI agents, gun fights and a wild chase in a hovercraft.

The French were more concerned with the greenhouse effect. Tremendous subterranean pressures caused an eruption of a lethal combination of chemical and radioactive elements. The implosion was so great that the planet separated into two, producing a twin planet called Earth B. A druid saw a vision of a survivor from Earth A who had amassed information about pollution. Thus, he assigned an environmental detective to Earth A to

save the survivor and bring him back to Earth B. Otherwise, Earth B would suffer a similar fate as Earth A within four days.

Due to its hypertextual nature, there were multiple avenues for branching. As such, the plot appeared complicated at first glance. However, in order to facilitate comprehension, the students decided to reduce the level of complexity of the plot by providing only two to four choices to the player at each stage. Undeniably, stories with two options were easier to play as it was easier to retrace one's steps to reread prior information. However, reducing the complexity of the plot did not lessen the challenge provided by the richness of the plots themselves. Hence, the richness and appeal of the content are imperative in sustaining interest although undoubtedly, the layout and other multimedia elements may complement and enhance its appeal.

Contrary to a traditional book whereby the reader could look back at the earlier pages, the player might find difficulty in retracing his/her steps if he were not concentrating as each step branched to various different paths. If the number of options were more than four, he might lose track of where he was in the entire network of links. Subsequently, even if the player was able to reflect and identify at which stage he made the wrong choice, he might not be able to revert to that particular point to attempt another link.

Characters and characterisation. The students feared that a complicated network of links might impede comprehension. Therefore, the number of characters was kept to a minimum. Four characters were created in the Malaysian scenario, two characters for the French version and ten for the American thriller. The characters were one-dimensional and action-oriented. Little is mentioned about the characters' feelings or thoughts. However, the mystery/suspense/thriller-based plots compensated for the lack of character development.

A matter of interest regarding logical links arose when one of the schools created hypertexts that posed as questions and answers regarding water pollution, which were separate from the story line. Thus, there was no natural flow from the story itself. Hypertexts in this context functioned as disjointed puzzles that the player would have to answer to proceed. Since there was no natural flow from the story, the possible effect was that the player could get distracted from the story line or even resent answering the hypertexted questions. It would then be a matter of whether the story line was sufficiently interesting to maintain curiosity, challenge and the player's fantasy of winning.

Layout. As the pace of the game had to be fast in order to maintain a sense of suspense and thrill, most of the narrative on each Web page were short and self-contained. Each page could stand by itself while being linked logically to previous or subsequent pages. This consideration took up most of the students' time, as they had to ensure that the contents of each Web page were adequately developed.

With regard to design layout, the Malaysian students decided to use a thematic approach. The background as well as the pictures included in each web page corresponded with the textual content being developed. For example, if the story revolved around activities in a mangrove swamp, then the background for the Web page was that of a mangrove swamp. This was deemed necessary to create the mood for the story as well as to enable the player to visualise himself or herself in the context.

The extent to which other multimedia elements such video or music should be included was another pertinent consideration. Since bandwidth would determine the speed for downloading these elements, video was not used. It would be too slow to download, thus putting off any interest to view the pages. The importance of immediate information gratification cannot be understated as the higher the degree of satisfaction that meets the player's curiosity, the more likely the reader/player is likely to understand and remember the information presented. Thus, timely information retrieval will contribute to a higher rate of retention and more effective learning. This implies that the subsequent pages should appear as soon as possible in order to sustain interest in exploring further (Bonime & Pohlman, 1998). To increase the appeal of the web pages, some Java applets were used. These however, served merely cosmetic purposes. The story was the actual point of interest.

There were sufficient navigational links to go to the previous or the next page but there was no point of access for the player to quit the game or to branch off to another link. Thus, the links appeared to be rather linear in nature along the pre-determined path set by the author. Perhaps more discussions in collaboration with others not directly involved in the group should be held in order to test out the viability of the links. Having external observers to provide detached and objective comments would therefore be imperative in empowering and enlivening the player's interaction with the game.

Considering that the students needed accurate information to provide an appropriate context for their story, the Malaysian students initiated their own research by organising a trip. They went to the Irrigation department dealing with water pollution, a mangrove swamp and a recently rehabilitated river, which was previously the most polluted river in Malaysia, to gather information and pictures for the web pages.

After the writing process

Reflection on the benefits of collaboration. The sample Malaysian students were more aware of the audience they were writing to and for, more enthusiastic about sharing and enriching each other's ideas, able to alleviate each other's fears regarding the use of technology and were motivated to learn more by initiating their own research. They were also thrilled with the mere prospect of being on-line, achieving a monumental victory by winning fourth in the contest although they knew nothing about web page design prior to the contest. They were amazed at what technology could do, enabled them to do and were eager to participate in future networked collaborative projects (Lee & Zulkifli, 1998).

In short, the Malaysian students enjoyed the process of collaboration with students from other countries as well as the challenge of competing in an international competition. The novelty of the competition itself motivated them to figure out what they needed and how they should achieve these. This form of extrinsic motivation complemented avenues for intrinsic motivation stimulated by the interactive collaboration among the schools and among the students within the school. Hence, choosing and modifying tasks to suit the students' interests are pertinent issues that need to be looked into to simulate an actual interactive learning environment.

Reflection on problems. These problems were identified as lack of access to the Internet, regard for technology as peripheral to meaningful learning, difficulty in gauging and maintaining their partner's level of commitment, and the unfamiliar use of graphical-based chat software (Lee & Zulkifli, 1999).

There were also problems in terms of group dynamics as initially, some students were more dominant and refused to consider others' opinions. One of the student leaders however, suggested breaking up into smaller groups in order to discuss their ideas before presenting them to members of other groups. An amicable consensus was then reached.

All this while, the teacher functioned as facilitator. He suggested alternative means for accessing the Internet, provided opportunities for active discussion with experts in web page design, and encouraged them to consider possible problems with the server. In addition, he prompted them to consider alternative reasons for problems in communicating with their peers and their overseas counterparts before suggesting that these problems might be due to differences in approach, differences in age and even difficulty in accessing the Internet. Exploring possible reasons for these difficulties helped them to be more tolerant and open to suggestions. Thus, empowering the students propelled them to be independent thinkers. They elaborated and clarified their ideas and were constantly assessing their progress through requests for feedback.

Pedagogical implications

A review of the curriculum, assessment and teacher training for schools were already in process during the project. However, it cannot be understated that adequate support from the administration is imperative for any form of experimentation involving technology as these interrelated factors play a major role in determining the manner of teaching and learning that eventually take place. Hence, every party in the learning equation should be convinced of the value of providing diverse avenues for purposeful and meaningful interaction and consider its implementation wisely.

With this in mind, Brooks and Brooks (1995) suggest that administrators and curriculum developers should be aware of up-to-date research findings by attending seminars, so that adoption of ideas presented is more likely and adaptation from these ideas is more informed. Furthermore, teachers should be provided with more opportunities to develop their skills rather than rely merely on textbooks and workbooks. Another consideration is the formulation of alternative forms of assessment such as for project-based assignments that are more subjective in nature. The specific skills targeted at must be clear to the teacher and the students. Although much value is accredited to the integration of technology, teaching and learning objectives and proper planning should be the primary concern for any successful and enriching lesson.

Conclusion

The learning content, activities, objectives and environment are interrelated parts of the learning system which are not mutually exclusive factors. This implies that the process of formulating and testing hypotheses in order to construct knowledge cannot be considered as an exclusive occurrence independent of its environment (Duffy & Jonassen (1992).

Since problem-solving tasks and computer-mediated communication have shown much potential as playgrounds for exploration and discovery, we need to be receptive to research findings to initiate meaningful and purposeful action. In addition, we should not regard change as irritating or as a threat, for waves of change can function as catalysts towards the growth of a dynamic and authentic environment for learning.

Thus, the potential of a constructivist classroom in stimulating multi-dimensional, self-directed learning and in providing scaffolds for interactive meaningful construction of knowledge should be recognised and encouraged through proper planning and adequate guidance that form the crux of any curriculum development and lesson planning. As Berliner (1992) concludes, the process of nurturing a desire for lifelong learning involves providing opportunities to learn more. Thus the focus on intelligence and assessments of performance should not be at the expense of meaningful learning. Since an interactive multi-dimensional classroom encourages multiple resourcing and analysis of information that will enhance the development of a wider range of abilities, activities or projects that simulate the real world in terms of depth and complexity should be strongly considered.

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