DOCUMENT RESUME

ED 458 870 IR 021 022

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TITLE Interaction: The Key to Successful Distance Learning.
PUB DATE 2000-06-00
NOTE 9p.; Paper presented at EdMedia 2000: World Conference on Educational Multimedia, Hypermedia and Telecommunications (Montreal, Canada, June 26-July 1, 2000).
PUB TYPE Reports - Descriptive (141) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Computer Mediated Communication; *Cooperative Learning; *Distance Education; Educational Technology; Elementary Secondary Education; *Instructional Design; *Interaction; Interpersonal Communication; World Wide Web
IDENTIFIERS Collaborative Learning; *Learning Environments; *Web Based Instruction

ABSTRACT

This paper discusses the impediments to distance education (DE) programs and the critical value of interaction and dialog in DE learning environments. The types of interaction to be considered when designing a DE program are listed, including interaction to increase learning, to increase participation, to develop communication, to receive feedback, to enhance elaboration and retention, to support learning control/self-regulation, to increase motivation, for negotiation and understanding, for team building, for discovery, for exploration, for clarification of understanding, and for closure. The following examples showcasing DE K-12 support curriculum projects from the National Aeronautics and Space Administration (NASA) are discussed with respect to their interaction and collaboration: NASA Quest/Sharing NASA, Learning Technologies Project, and EarthKAM. (Contains 15 references.) (MES)

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Full Paper presented at
EdMedia 2000: World Conference on
Educational Multimedia, Hypermedia and Telecommunications

International Conference hosted by the Association for the Advancement of Computing in Education
http://www.aace.org/

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The purpose of this paper is to discuss the impediments to distance education (DE) programs and the critical value of interaction and dialog in DE learning environments. Examples showcasing DE k-12 support curriculum projects from the National Aeronautics and Space Administration (NASA) will then be discussed with respect to their interaction and collaboration.

Impediments to Distance Education

Distance education (DE) has usually been defined as the separation between instructor and student, whether temporally or by spatial distance. While this physical and temporal distance is a fact, it erroneously limits the factors affecting learning at a distance. Transactional distance more aptly describes the relational separation between learner and instructor and is based on the interplay between the environment and patterns of behavior or dialog between the learner and teacher and the autonomy of the learner (Moore, 1996).

With the physical separation of the leaner and instructor there are psychological and sociological implications that limit communication (Wolcott, 1996). In effect the psychological distance may generate a feeling of isolation for the student and hinder the development of rapport between the learner and teacher. Wolcott (1996) states that it is this rapport that allows the learning discourse between teacher-student and student-student relationships to occur. Social presence or acceptance as perceived by the distance learner is a significant factor for consideration (McIsaac & Blocher, 1998) and should be included in the design process. The gender neutrality DE affords (Gross, Muscarella, & Pikl, 1994) may also help to foster increased social interplay if interaction is intentionally incorporated. Unfortunately, distance education programs malfunction due to their lack of consideration for the human dimension (Spitzer, 1998). While tremendous strides have been made in telecommunication hardware, Spitzer (1998) states that it is the social interaction level between humans that will determine if a DE program fails or succeeds.

Necessity of Interaction

Moore (1997) describes the necessity of a purposeful instructional dialog, which facilitates and increases the interaction between student-student and teacher-student communication. In a purposeful dialog environment all learners are active participants, listening and building upon the contributions of other individuals. Moore continues by saying that dialog is also influenced by teacher and learner personality and content. Thus, intentionally designed collaborative opportunities should be incorporated into the instruction for distance learning environments to be most effective. As dialog and learner control increase, transactional distance decreases (Saba & Shearer, 1994). For learning is not an objective search for prescribed knowledge, but one that is experienced and formulated based on how we interact with our environment and others (Duffy & Jonassen, 1991).

Equally affecting the exchange of dialog or interaction between participants is the way a distance learning program is structured. Selecting the right instructional strategy, such as that of interaction facilitates learning of the higher levels of cognition such as: analysis, synthesis, and evaluation (Weston & Cranton, 1986). Programs that are extremely rigid and that do not allow flexibility for student contributions, interactions or discussions are detrimental to the learning outcomes desired (Moore, 1996; Parker, 1999).

Several forms of social interaction are possible in a DE environment, all of which should be considered during the instructional design phase of a course. Interaction may occur between the following categories: learner-instructor, learner-learner, and learner-content (Moore, 1992; Wagner, 1997). A fourth dimension of interaction was additionally added, that between the learner and the interface(Hillman, Willis, & Gunawardena, 1994). When designing instruction one should first look at the intended instructional outcomes desired for a learning experience, analyzing the type of learning that is desired (verbal or intellectual skills, psychomotor skills or attitude changes), then select the appropriate type of interaction that will facilitate this type of learning (Wagner, 1997). Wagner provides a fairly comprehensive catalog of the diverse types of interaction possible when working in a DE environment.

Types of Interaction:

Interaction of the following types should be considered when designing a DE program (Wagner, 1997):

1. Interaction to increase Learning
2. Interaction to increase participation
3. Interaction to develop communication
4. Interaction to receive feedback
5. Interaction to enhance elaboration and retention
6. Interaction to support learner control/self-regulation
7. Interaction to increase motivation
8. Interaction for negotiation and understanding
9. Interaction for team building
10. Interaction for discovery
11. Interaction for exploration
12. Interaction for clarification of understanding
13. Interaction for closure

As can be seen from the list above, there are a myriad of purposes for which interaction may be utilized in DE. To crystallize these types of interaction into authentic teaching methodologies one should refer to the book authored by Tom Cyrs: *Teaching At A Distance* (1997), which provides a multitude of ways to engage the learners while separated physically or temporally. Through things like dynamic role playing or debate, detailed case studies, authentic problem solving, engaging panel discussions, group presentations, peer teaching or mentoring, and creative projects (both individual and collaborative), one may provide possibilities for the many type of interaction Wagner (1997) references.

Finally, the role of context plays a critical part in not only distance education, but all instruction and should be addressed when designing specific types of interaction and methodologies (Tessmer & Richey, 1997). Context may be described as the situation that surrounds or encapsulates the learning environment. Tessmer and Richey (1997) break context into three components or types: orienting, instructional and transfer. The orienting context is presented before the learning event and readies the learner for the desired instructional outcome or objective (information, relevance, examples). The instructional context is the learning conditions and scaffolding provided during the learning event (content presentation, practice and feedback), while the transfer context allows the learners to apply the newly acquired skill, knowledge or attitude outside of the original instructional event. In closing the discussion, there are numerous types of learning contexts that instructional designers working in DE may draw upon, such as a situated exploration of an environment, creation of a product, inquiries designed using a simulation, communication among participants possibly through gaming, or collaborative engagement through real problem-based scenarios (Sherman, 1998) . By embedding the components of the DE instruction within an appropriate context, varying levels of interaction and methodologies may be enhanced within the orienting, instructional and transfer sequence.

With the impediments to distance education and the necessity of interaction in DE environments discussed, a look at several instructional examples from NASA's k-12 education program will follow. It is hoped that by presenting authentic examples of educational programs that facilitate interaction, practitioners will be able experience first hand the theories posited by the research in this paper. As each program is presented, a description of the level and type of interaction will be discussed in addition to an analysis of the educational context. The first NASA program presented below takes advantage of the interaction between teacher-student and student-student to increase learning, participation, team building, motivation, negotiation and understanding.

NASA Online Interactive Projects: NASA Quest/Sharing NASA

http://quest.arc.nasa.gov

Senator Al Gore originally funded this project in 1991 as part of the NASA High Performance Computing and Communications (HPCC) program. Capitalizing on the motivational aspects of collaborating/communicating with NASA individuals, teachers have expressed the value of the "Sharing NASA" supplementary support curricula aligned with the National Science Education Standards (NSES). Sharing NASA provides "real-world" authentic contexts and situated learning opportunities that connect the science content and process skills currently taught in the classroom, transcending the physical and temporal classroom limitations.

At the link above you'll find a listing of online collaborative NASA projects where one may participate in a variety of conferencing opportunities with NASA scientists, engineers, researchers and support personnel via email, synchronous chats, asynchronous threaded discussions, and streaming video. In addition to the interaction opportunities, online activities, project background information, mission updates, and biographies are available.

A combination of software solutions and "Smartfilter" designates (volunteer teachers, paid employees) manage the enormous influx of inquiries, aggregating common questions and facilitating the asynchronous interaction between the limited time of the NASA employee participants and the classrooms across the nation.

Past examples of "Sharing NASA" projects are archived and available online. One example will now be discussed.

Live From Mars (July 1996-December 1997)
http://quest.arc.nasa.gov/lfm/index.html

Created in conjunction with the "Passport to Knowledge-Live From" series, the "Live From Mars" Sharing NASA project had a host support curriculum with the following programmatic categories: featured events, live video, photo galleries, questions, chat, kids corner, teacher's lounge, background, Mars team (biographies, images), and what's new.

One featured event Weather Worlds challenged student classrooms from around the country to debate what key weather measurements and instruments they thought were most important to gather here on Earth (similar to decisions the NASA Mars Pathfinder scientists had to decide for the surface of Mars). Classroom submitted their proposals online with justifications for debate. For example, if a classroom felt temperature was a worthy measurement, they then had to figure out protocols and procedures on how, when and within what range and frequency they should collect temperature data.

Electronic individual class results were collected by the "Sharing NASA" personnel, placed in a spreadsheet, and responses aggregated and debated online. From these collective results, final instruments and protocols were tallied and presented.

Ironically, this type of interaction doesn't necessitate high bandwidth connectivity or a computer lab. The learning is done in the classroom facilitated by the teacher, then submitted via email for presentation and debate. Current "Sharing NASA" projects include:

1. Space Scientists Online
2. Aero Design Team Online
3. Women of NASA

The next NASA educational curriculum support area that will be discussed focuses on the interaction between the learner and the content, and learner-interface while also integrating teacher-student and student-student interactions to facilitate learning, exploration, feedback, and elaboration and retention.

NASA's Learning Technologies Project:
http://learn.ivv.nasa.gov
Here you'll find the entry page to approximately 50 NASA funded Internet projects focusing on interaction between the learner and content. NASA is supporting the development of projects in disciplines like Agriculture, Aeronautics, Aquatics, Earth Science, Tourism, and Space Science. At this site one may search for projects by discipline or state. One project from NASA's LTP will be referenced below.

> NASA Glen Research Center:
> FoilSim (Basic Aerodynamics Software)
> http://www.lerc.nasa.gov/WWW/K-12/aerosim/index.html
>
> FoilSim is dynamic simulation software that allows students to interact and control the parameters of airflow around a wing or baseball by varying the airspeed, altitude, thickness, camber, and area. Students also have learner control over the placement of the probe gathering aerodynamic data, and receive immediate feedback via a Plotter View Panel that depicts graphical changes in surface pressure, speed at surface and lift. The student can also visually see how far a curve ball would "break" across home plate for various elevations (Cleveland, Denver, Mt. Everest). This Java applet (Mac or PC) when used in conjunction with guided questions and the necessary content background facilitates the learning of the factors that influence lift.

The final NASA educational project that will be discussed concerns the interactions between learner-interface, learner content, and learner-learner while enhancing learning, communication, feedback, team building, exploration and discovery.

EarthKAM
http://www.earthkam.ucsd.edu/
EarthKAM is an opportunity for students to investigate Earth from the unique perspective of space via digital photographs they request during live space flights and from previous mission image archives. Piloted on 5 previous space shuttle missions, EarthKAM will be the first operational payload on the International Space Station.

In essence, students plan authentically real investigations that can in part be answered from examination and manipulation of remotely sensed images. For example EarthKAM can be used to answer questions involving real world problems like deforestation, beach erosion, urban crawl, etc. This educational context actually mimics the work done by real scientists.

Uniquely designed web interfaces allow students to search from images either visually by geographic location, by image index number, by mission, by school, or by geographic name (China, Nile River, etc.). Once a particular image is selected, students can then examine the image by zooming in/out or panning left, right, up, and down. To place the image in the "big picture" a student can overlay the digital photograph onto a composite map showing the elevations and contours of the surrounding areas or a Jet Navigation Map (JNM) displaying the location and names of major geographic reference points (rivers, cities, etc.).

Also available is the ability to view the map against the animated cloud cover that was present (within 3 hours) on the day the image was taken using weather satellite remote sensing image overlays. Finally, with the use of a VRML browser plug-in like COSMO, the student can take a composite map (image overlaid against surrounding colored contour map or JNM) and visualize the image in a 3-D environment. This environment allows the student to fly by, fly over, fly under, or fly around the image with the elevations literally portrayed with vertical depth as well as 2-D color. Finally, using free image editing software (NIH image), student can label their photographs and make measurements like scale distances, area, and perimeter for quantitative analysis.

This environment provides complete learner control and higher learner-interface, learner-content interaction. It should be said that while this program is extremely technologically savvy, without proper instruction and ancillary reference documents to facilitate worthy investigative questions, image manipulation alone merely becomes a novelty toy.

Summation:

For distance education to be effective, design efforts must consider the impediments that hinder effective learning such as: transactional, psychological and sociological distance (Moore, 1996; Wolcott, 1996). Intentionally designed DE programs that foster interaction and dialog between the student-teacher and student-student enhance learning and emphasize specific learning skills if properly facilitated (Wagner, 1997). There are a myriad of documented methodologies that may be employed in distance environments to facilitate rich interaction like role playing, panel discussions, case studies and authentic collaborative problem solving (Cyrs & Conway, 2000). Several NASA K-12 education support curriculum projects seem to emphasize interaction at various levels and were described herein with respect to their type of interaction and learning context.

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EFF-088 (Rev. 2/2000)