Influences of Organizational Culture On The Use of Computers in Introductory Physics Courses

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Kajian etnografik ini bertujuan mengkaji pengaruh budaya organisasi institusi pengajian tinggi terhadap penggunaan komputer dalam pengajaran kursus-kursus pengantar fizik. Kajian ini dijalankan di Amerika Syarikat di sebuah universiti yang terkenal dalam penyelidikan dan di sebuah kolej kommuniti yang mementingkan pengajaran. Hasil kajian ini menunjukkan komputer digunakan lebih meluas di kolej kommuniti berbanding dengan di universiti berkenaan. Budaya organisasi didapati mempengaruhi pensyarah-pensyarah di institusi-institusi berkenaan samada menggunakan komputer dalam pengajaran kursus-kursus pengantar fizik atau tidak.

Introduction

In the teaching of physics, computers have been used for more than a decade. Computer software have been written to teach concepts, facts, and problem solving. Initially programs were written for large, time-sharing computer systems like PLATO at the University of Illinois (Kearsley, Hunter, and Seidel, 1983). In the late 1970's, development of computer software has spread to include microcomputers. This is mainly due to the affordable price of microcomputers in the market (Balkovich, Lerman and Parmlee, 1985). There are programs available to simulate laboratory experiments, to draw graphs, to collect and analyse data as well as others. In short, computers are currently being used for a variety of purposes in the teaching of physics. Nevertheless, there is evidence that computers are not widely used in the teaching of physics perhaps due to the culture of the university or the organization, which this research will try to address. Thus, this research attempts to find the influence of culture in a university and a community college on the use of computers in the teaching of introductory physics.

The Various Uses of Computers in Physics Teaching

The use of computers in physics teaching is being rapidly changed by the availability of microcomputers with increasing power at decreasing cost. The various use of computers in physics teaching include drill and practice, simulation, data collection and analysis, and programming. Drill and practice programs are probably the most common educational application of computers in physics teaching. These programs are used for exactly the purpose implied in their name. Faculty members assign students to use these programs for drill and practice in solving problems in dynamics and optics.

As a student starts a drill and practice program, the computer usually asks where the student would like to begin in the skills sequence. For some programs, the computer already has a record of the student's most recently achieved level of mastery, so it automatically starts on the next level. In some programs, the faculty member chooses the level at which the student enters the program.

The computer then presents problems, either one at a time or a few problems. The student types in his response to the first problem. The computer checks the response and informs the student immediately if he has gotten the correct answer or not. Thus, students do not go on to the next problem practicing incorrect skills. If the answer is correct, the computer presents the next problem. On the other hand, if the answer is wrong, the computer usually directs the student to try again. For some students who repeatedly type wrong answers, the computer may instruct him to seek help. In some drill and practice programs, when a student misses a particular type of problem repeatedly, the computer may provide a brief explanation of how to do problems of that kind.

When the student has completed a problem set successfully, some program will summarize the student's performance. Generally, others simply inform the student that he has completed the set and ask if he wants to go on to the next set. Arons (1984) pointed out:

> efficient and well-planned drill, presented on an individual basis with immediate feedback reinforcing correct responses and correcting mistakes is a powerful instructional device. It is important in helping the student build bases of vocabulary and factual knowledge that underlie subsequent thinking, reasoning, studying, and problem solving.

This observation made by Arons is crucial for the success of drill and practice, especially in providing instant feedback so that students do not practice incorrect skills.

Another use of computers in teaching of physics is simulation. The computer is able to simulate a situation, give the student a chance to interact with the situation, and observe change resulting from the student's action. One example is an acceleration due to gravity problem, where students could observe and find out various conditions or situations on acceleration due to gravity. A second group of simulation programs allows the student to have a lab experience on the computer that could not be done in the physics laboratory because of time, dangers, or cost of equipment. One example would be on critical mass in a fission reaction in nuclear physics. Finally, simulation programs allow the exploration of hypothetical situations not encountered in the real world. For example, it is possible to create simulated worlds that behave according to the primitive pre-scientific conceptions of novice students. Students, left free to explore such worlds, would then quickly discover in what ways their own conceptions are not adequate to explain phenomena in the real world. For example, simulation programs can sketch the resultant orbit of a planet around the sun after students have fed in a new law of gravitation in the program.

Hartley and Lovell (1977) provided the basis for using simulations in science teaching in the following way:

> In the sciences many concepts are not only difficult to illustrate but the relationships between them are represented in formal and symbolic terms. Many students find it difficult to link these theoretical terms with the conventoinal language which describes every day experience. Thus to make scientific phenomena accessible to the intellect, the teacher must illustrate the concepts, build up the student's knowledge structures, and allow him to elaborate them in ways which show the nature of the underlying principles. For these reasons, providing "simulation" exercises through the microcomputer has proved a useful and popular development in science teaching. The idea is that the program provides a "working model" of the scientific system. In fact, it is the formal representation of the system, i.e., a set of equations or a quantitative data base which can be sampled, which is embodied in the program. Usually the student cannot edit or amend the program itself, but he can manipulate the input values and observe the effects on the output displays. (cited in Walker and Hess, 1984)

Simulation programs can be useful tools for students and teachers in learning and teaching science (Hartley and Lovell [1977]).

One of the most exciting uses of the computer in physics instruction is in data acquisition and analysis in the physics laboratory. With a microcomputer equipped with a thermocouple, a student can gather actual physical data such as temperature in the cooling curve experiment of napthalene for every second if needed; store the data; operate on or graph the data, and print out the results. Using a photocell counter, a pH meter or other data acquisition instruments interfaced to the microcomputer, a wide range of experiments can be conducted. With the microcomputer students can gather data over and over again in the same manner without bias and tiring. The computer can keep on gathering data when it is not possible for students to continue. Also, the data can be collected many times faster. The data obtained can be displayed instantaneously. Results obtained can be put in tabular or graphic form and can be plotted to show the relationship between the variables. Students can do further investigations which would not be possible without the computer because there would not be enough time to redo the experiment. Thus, this tool allows the student to investigate many more examples with greater speed than is now possible (Tinker, 1981).

Certainly, this will free the student from doing the same task repetitively, and it can help the student in his conceptual understanding of the concepts involved in the experiment (Hawkins, MacIntire, and Sutton, 1987). Programming requires users "teach" the computer, in contrast to being tutored or using the computer as a tool. The users must communicate with the computer in a language it understands. As a programmer, the student assumes responsibility for his learning and this according to Papert (1980), makes learning qualitatively different. The best example is the LOGO project developed at the Massachusetts Institute of Technology. DiSessa (1982) discussed how LOGO is used in learning some concepts of elementary physics. In this program, students control the movement of the "turtle" by "pushing" it with forces of specified direction and magnitude. The turtle will move according to the laws of Newtonian physics on the screen as if it were an object on a frictionless surface. DiSessa found students who undergo such experiences, develop an intuitive understanding of elementary mechanics that is difficult to achieve in traditional -learning milieu. Thus, in DiSessa's (1982) study students learned control of the computer and they gained insights into their own learning processes. They acquired control over themselves and their own thinking. They learned how to learn. In this regard, programming seems to provide students an opportunity to learn and it is also cost- effective according to Taylor (1980).

This section provides background on the current development of using computers in teaching physics. The four different types of use of computers in teaching physics has been discussed and it and it indicates that computers if used appropriately computers is effective in teaching physics. However, the reason that is not widely used could be due to the culture of the institution or organisation.

Organizational Culture

Culture helps an organization maintain its unique character. Ouchi (1981) stated that organizational culture communicates belief and values that give meaning to life within the organization. Pascale and Athos (1981) described organizational culture as a "bass clef" that conveys meaning to employees, as a "compass" that provides direction, and as the "shared values and spiritual fabric" that bind the organization together. They describe how an organization's culture helps employees know how to behave and make meaning or sense out of the behavior of others. Barrett (1984) discussed the dependence of a person on his cultural milieu, and that the person must conform if he is to be approved and accepted by his fellows. Kuhn (1962) has shown how scientists, once they operate under a common paradigm (a theoretical model for research), come to share the same set assumptions about the world. They begin to think in similar patterns and make or fail to make parallel discoveries or innovations simply because they have similar outlooks, values, and beliefs.

Perrow (1979) described the "institutional school" of organizational theory. This is associated with Selznick (1957) who differentiated institutions from organizations. The latter (organization) more clearly reflects a formal system of rules and objectives while the former are more a natural product of social needs and pressures. Perrow viewed institutions as "responsive, adaptive organisms." Administrative ideologies and values produce a distinct identity for the institution, and institutional leadership defines a clear mission or goal that guides behavior. Through the process of institutionalization, values infuse the organization and it develops a distinctive character which takes on a life of its own. The institution becomes valued for its own sake (Perrow, 1979).

Harrison (1972) wrote about organizational character, which is closely related to organizational culture. While not discussing "culture," he stated that an organization's character arises from ideological issues. Ideologies are a central part of culture (Pettigrew, 1979). Harrison described how values and ideologies aid in the understanding of organizational behavior and conflict. He reflected the earlier concern for quantification and postulated four ideological orientations (power, role, task, and person). Harrison applied his classification to decision making, human resource utilization, and environmental interaction. His interest is in exposing organizational characteristics so that individuals can better understand the organization and potential sources of organizational conflict.

Pettigrew (1979) explicitly stated that he was interested in a family of concepts called organizational culture. He defined culture as "the amalgam of beliefs, ideology, language, ritual, and myth." Pettigrew felt that these cultural concepts explain and prescribe behavior. He stated that culture codifies meaning in a publicly and collectively accepted manner. He placed great emphasis on culture because it is part of the longitudinal growth and development of organizations. An organization's founder imparts direction and orientation through the organizational culture. For example, the culture of a physics department in an institution is shaped by the collective beliefs of its members and the influences of other physics departments at similar universities or colleges. It is also shaped by the culture used for promotion and tenure, which at research universities is influenced by many factors including publication and judgements of quality in research. Clark (1971, 1972) provided one of the best applications of organizational culture to colleges and universities. He focused on one aspect of organizational culture that he called "saga, a collective understanding of unique accomplishment in a formally established group". The important characteristics of saga are that it arises from the group, and it has a special meaning for them. Moreover, saga provides a foundation for the environment within the organization. The saga provides information about the culture or the institution's beliefs, ideology, and values. Saga is important because it binds individuals to the organization. It structures their beliefs about the organization. It tells them what the organization values, what has meaning, and what is of special importance. Thus explication of an institution's saga is one method of exposing the underlying values and ideologies of the organization's culture.

In his book The Academic Life, Clark found that professors at research universities who were perceived as outstanding in academics were those who placed research up front in their agenda and let teaching trail along as a way of imparting the results of research (Clark, 1987). However, according to Clark (1987), at community colleges, the professors felt that outstanding faculty are those who are student-centered, in other words those for whom teaching takes precedence over research. He also found professors at comprehensive universities thought that to be an outstanding faculty one needs to be both an effective teacher as well as active in research. His findings illustrate the belief of professors to be considered outstanding academically at the two different types of higher institutions. Nevertheless, Boyer (1987) suggested, "faculty who pursue research are acknowledging the realities of academic life and of good scholarship as well." In his national survey of college professors, Boyer found that 75 percent said that it is difficult to get tenure in their department without publishing. This has a chilling effect on classroom teaching and instructional development. Jencks and Riesman (1968) showed the price that is paid when research is rewarded and bad teaching is accepted:

> Not doubt most professors prefer it when their courses are popular, their lectures applauded, and their former students appreciative. But since such successes are of no help in getting a salary increase, moving to a more prestigious campus, or winning their colleagues' admiration, they are unlikely to struggle as hard to create them as to do other things ... Many potentially competent teachers do a conspicuosly bad job in the classroom because they know that bad teaching is not penalized in any formal way.

Freedman et. al. (1979) commented, "Frequently, for example, faculty members are assured that teaching effectiveness will be given as much weight as research or publication in tenure and promotion decisions, but the practice does not match the promise."

Pascale and Athos (1981) described that in situations involving conflict, decision making, or change, one can observe culture influencing behavior. This is particularly significant to thisstudy, because the use of instructional computing is perceived as a change or innovation and thus is very much being influenced by the values and beliefs at the two higher institutions in this research. Furthermore, the culture aspect of organizational behavior has not been used to understand the usage of computers in teaching. Thus, organizational culture is used to help the researcher interprete the data collected in this research.

Research Methods

Ethnographic research also known as naturalistic, qualitative, and field research was the method used for this study (Bogdan and Biklen, 1982). The ethnographic research design is based on theoretical assumptions that meaning and process are crucial in understanding human behavior, that descriptive data are important to collect, and that analysis is best done inductively; and data are collected through participant observation, interviews, and document analysis.

The research began with informal interviews with key people at two tertiary institutions who were identified to have initiated the use of computers in introductory physics courses. As the research continued, more than twenty people were involved, including all faculty members teaching introductory physics courses, faculty members who had shown interest in using computers in their teaching, chairman of physics departments, and a provost of a university. The researcher became a regular visitor to both locations, observing classes, talking with faculty members casually, and interviewing faculty members and administrators. Interviews with faculty members was the main source of data acquired.

Thus, this research was carried out using an ethnographic research approach that: (1) emphasized descriptions of activities, based on observations of faculty members as well as written documents; (2) study of people's perceptions, using interviews and casual conversation with faculty members, and key administrators; and (3) inductive analysis of these data. During this research, the researcher used triangulation to cross-check the validity of data collected.

The data collected were simultaneously analyzed, and as this was done, new questions were raised that modified the focus of the research (Erickson, 1986). This process helped the researcher to be critical in carrying out the research, and thus allowed this research to be done with more efficiency. More comprehensive and intensive analysis of data was done at the end of the research. At these junctures, additional notes were made to record new patterns that were identified. This necessitated that the researcher returned to the field to verify these new patterns.

Research Sites

The two institutions that were selected for this research were Alpha University and Beta Community College, all pseudonyms. These institutions are in the midwest of the U.S.A. Alpha University is a leading research university in the nation. On the other hand, Beta Community College focuses its resources for teaching purposes and virtually no research is conducted there.

Findings and Discussions

At Alpha University, the use of computers for instruction in introductory physics was limited. Computers were used in the laboratory to perform experiments and analyze data. In short, computers were used as a tool in the laboratory. However, the physics faculty at Beta Community College appeared to utilize computers relatively more than at Alpha University.

Most of the faculty members at Alpha University viewed themselves as physicists rather than physics educators. They viewed themselves as doing research in physics areas such as solid state and nuclear physics. Thus, they did not devote their time to doing research on teaching physics, such as finding out the most effective methods for teaching quantum mechanics. Consequently, they were involved in professional organizations that were active in physics research rather than in organizations that were active in pedagogical research.

One of the faculty members made a comment pertaining to the lack of interest toward teaching of faculty members in the Physics Department:

> It's difficult for us to develop a sophisticated software for instructionbecause we have no interest. We are not interested in social science that's why we went into physical science and what we are talking now is social science; how you teach is social science, even when you are teaching physics.

Another faculty member voiced his opinion about role of physics faculty in the department:

> We are all trained as physicists not as educators or social scientists. So our interests are in physics research rather than in educational research. Also, mostof us do not believe in social science or psychology which is part of educational research. And physicists are not up-to-date on literature in learning and teaching.

These two faculty members appeared to be typical of members of this department. They were clear about where their interests and background lay. They were not interested in conducting research in teaching of physics since they were trained to be physicists, not educators. Moreover, the faculty members recognized that they were not in tune with the recent development of research in learning and teaching.

The physics faculty members at Beta Community College were more interested in their teaching but did not do much in the research of physics teaching. As expected, the faculty members did not do any research in physics areas, such as nuclear theory and condensed matter physics. They attended all the state level professional organization meetings that were heavily involved in matters pertaining to physics teaching such as the American Association of Physics Teachers and the National Science Teachers Association.

One of the faculty members related this to me, "We are basically a teaching institution. I have 18 hours of class time and that does not include office hours and preparation time. I think it is an excellent place to do research on teaching." This is further supported by the chairman of the department who said that the department was heavily involve in teaching. The faculty member also pointed out that the college was an excellent place to do research on teaching. However, there did not seem to be much research in teaching going on in physics except for trying out new methods in teaching like instructional computing. The chairman also viewed this as true but he added that there was very little research of any kind undertaken by faculty members.

At Alpha University, the chairman of the Physics Department made this statement concerning the promotion of faculty members in the department which could suggest why computers were not widely used in introductory physics courses, "The faculty is promoted based on their research, teaching, and service. Research is weighted more than teaching and service when we consider a faculty for promotion. This is written in the by-laws of the department."

The chairman's remark suggested that the faculty members would more likely be promoted if they were active in their research. So, for non-tenured faculty members to be tenured, they must show their capability to be good researchers first, besides being able to teach and give public service. One faculty member made this remark:

> I think the faculty is valuable to the department by becoming valuable in his profession, in his research profession, because then he can move. When he can move, the university has to do something to keep him here, to show he is valuable. If he does innovation in teaching, the fact is only of value to the local college or university, but not to others. They are not going to be hired by other universities for that so the university does not have to pay attention to him. But if he does some new research in a scipline, other universities might hire him away. Whether he moves or stays, he wins because to keep him here, they have to give him pay raise and so on.

This preceding remark suggested that the faculty members would be likely rewarded if they were active in research rather than being innovative in their teaching. There is no doubt that being an outstanding researcher, the faculty member can bargain or negotiate for better pay, and also a better working environment. There was one faculty member in the department who was excellent in his research and was about to leave the department to join another university which offered him better pay and a better research facility. The department and the university bought him a VAX minicomputer to keep him and this amounted to a huge sum of money. But there were no cases where faculty members who were innovative in their teaching had job offers forcing the department to give incentives to keep them. It appears the opposite, because one of the faculty who was an advocate of using computers found that being innovative in teaching, the department did not provide incentives to keep him in the department. The department, however, gave some released time for him to develop the software and course materials but this seemed minimal compared to what an outstanding researcher received.

The provost of the university had this to say on this point, "I do believe that research and scholarship are ultimately what determines excellence of faculty at this campus. You know, you're not a scholar, (if) you're not engaged in keeping up with your field and finding out new things....So, the research scholarly dimension is crucial." This strongly showed that the university in general viewed research as a very important aspect of faculty life. Perhaps, it appears that the provost regarded research as important in the promotion of the faculty members. However, the provost later said:

> I think we should reward outstanding ability in any area but at the same time encouraging people in general to have a balance in research, teaching, and service. So, outstanding research should be rewarded, outstanding teaching should be rewarded and outstanding public service should be rewarded.

This statement suggested his willingness to view research, teaching, and service as important to the university. Thus, the Provost felt that the university should reward all faculty members who were excellent in any area, but most faculty members in the Physics Department did not agree that was happenning at that time. Also, as indicated earlier, the chairman felt the faculty members would be promoted or rewarded if they were active in research. It is pertinent that the department had a world class research facility in nuclear physics which was mostly funded by the federal government. The department research expenditures for the year 1985-86 amounted to more than 10.5 million dollars (see Table 1). This is an indication that the department was very active in research and perhaps suggested that the department would reward faculty members who were active in research. Undoubtedly, the faculty members were more attracted to do research for their professional development because of research support available and other incentives that were provided through pay raise, promotion, and prestige.

TABLE 1: Research Expenditure in Physics at the Four Institutions for 1985-86

Name of Institution	Research Expenditure in $	No. of Faculty Members	Research $/Faculty Member
Alpha University	10.5 million	69	152,174
Beta Community College	*	4	*
* No of Research Expenditure			

At Beta Community College where teaching was the main mission of the college, the physics faculty members were rewarded primarily for their teaching. It seemed that faculty members would be rewarded for their research in teaching physics, but not for research in physics. When I asked the chairman of the department the criteria for promoting faculty members, his reply was, "Teaching is the only criteria considered for promotion. The Dean receives faculty members' teaching evaluation scores from students and chairman of departments. Based on this, faculty are promoted."

Later, I asked the chairman if a faculty member who used computers for instruction was given a special consideration in promotion. His response was that not only would using computers for teaching be regarded as a plus in the faculty members promotion, but other innovations in teaching would be considered as well. This suggests that the faculty members would be rewarded for their innovative efforts in teaching. I discovered this was true when I found that two of the physics faculty members who were innovative in the use of computers for instruction left the department a couple of years ago. They were promoted to take a responsible position related to computer use in the college. One of them was promoted to be the coordinator of computer assisted instruction for the School of Arts and Science and the other was promoted to become the system manager of the college's mainframe computer. This however, did not support the continued use of computers in teaching physics courses and one of the faculty members related this:

> I hate to say that we're getting away from instructional computing. We're using it less and less. Because for years, there were two people in physics who were very knowledgable with the computer and now there aren't. They both had left, one of them is the CAI coordinator and the other became system manager for the VAX. The people who really had the vision to use computers happened not to be here anymore.

This is an interesting comment because the faculty were telling me this was the reason there was limited use of computers for instruction in physics at the college. Without the competent faculty members in using computers for teaching, it is probable to expect that both development and use of computers would fall off. The chairman of the department and faculty members also told me that physics research would not be counted for promotion, but research in physics teaching would be considered for promotion. However, there was no on-going research in the teaching of physics during my study and only a small effort in the development of new physics teaching methods.

Conclusions

The culture of an organization communicates values and beliefs that provide meaning to life in the organization (Ouchi, 1981). In other words, organizational culture helps employees to determine their behavior and to make meaning or sense out of the behavior of others. Barrett (1984) suggested that an individual is subjected to conform to the culture of the individual's environment for the individual to be accepted by fellows. In this research, the faculty members at the two institutions must conform to the culture at each of the two institutions in order for them to be recognized and also rewarded.

The values, beliefs, and mission at each school influenced how the college and university used computers in the teaching of introductory physics in this study. Each institution used and promoted computers for teaching that was congruent with its culture and supportive of its fundamental goals and saga, or a common belief of an established group that was unique. At the leading research university, there was more emphasis on research instead of instructional development or teaching in general. Clark (1987) also found similar notions by professors at research universities. In this study, the emphasis on research and consequent deemphasis on instruction was obvious in the overall use of the resource. As a result, the faculty members and administrators were not very enthusiastic in using computers for teaching. The faculty members and administrators perceptions' of their roles were shaped by the organizational culture of the universities. This was especially important knowing that most of the resources were channelled towards research, and that promotion, tenure and status all depended on research productivity. Therefore, the reward structure in the physics departments of this university stressed research instead of teaching. Consequently, the faculty members here were more interested in doing research than in devoting their time in developing computers for teaching.

On the other extreme was Beta Community College. Here teaching in general was their main mission. This is in agreement with Clark (1987). The data showed that there was more use of computers here than at Alpha University. Contrary to what happenned at the leading research university, at Beta Community College the resource was used for teaching or instructional development and this was in agreement with the mission of the college. Thus, faculty members were promoted and given tenure based on their teaching performance. Consequently, this created an environment where the faculty members were enthusiastic in their teaching. Thus, it was not surprising to find more use of computers in teaching here than at other settings. Nevertheless, this usage was still limited to the laboratory.

Organizational culture played a major role in understanding the use of computers in teaching physics in this study. This framework helped the researcher to understand the factors that influenced the use of computers at these settings. Thus, it was true according to Pascale and Athos (1981) that culture of an organization influenced behavior of individuals in situations involving change, in this case, the use of computers for teaching in the introductory physics courses.

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