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ABSTRACT

This paper uses the data from a longitudinal study to assess the impact of technology introduction in liberal arts education at a non-technical small private university in the United States. The data was collected over four academic years, and this "post hoc" analysis uses the data collected in the spring of 1999 from a sample of students who responded to a questionnaire that was mailed to them. The questionnaire included nearly 50 attitude items measured on a five-point Likert-type scale. Of these 50, there were several items that were specific to the local conditions of the university. The remaining items are analyzed in this paper. Analysis included two components: first, a factor analysis that elicited 4 factors on the basis of 25 items that were selected as the general attitude items in the questionnaire, and second, the items that loaded on the same factor were subject to reliability tests to explore the levels of reliability of the similar items. The 25 items were analyzed using a varimax rotation and this resulted in four major factor loadings. Four tables report the factor loadings, Alpha value for each factor, Alpha values after dropping item with the least weight, and attitude items. The results suggest that there are specific clusters of items that can be used to measure the effectiveness by using the surrogate measure of attitudes towards the use of computers in teaching. (Contains 17 references.) (AEF)

Developing a questionnaire to measure the effectiveness of computers in teaching

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Abstract: This paper uses the data from a longitudinal study to conduct a series of factor analysis to test the reliability of a set of items to measure the effectiveness of the use of computers in higher education. The results suggest that there are specific clusters of items that can be used to measure the effectiveness by using the surrogate measure of attitudes towards the use of computers in teaching.

Introduction

One of the thorniest problems following the introduction of computers in education has been assessing the efficacy of technology in improving the quality of education. There is little doubt that technology and education are now intimately associated and there is a growing application of technological tools in the educational process (see, e.g., Brown, 2000; Oblinger and Rush, 1997). This increased application of technology is constantly calling for the need for better assessment of the effects of technology and there are relatively few good methods of evaluating this efficacy (Reeves, 1998; Woodrow, 1994; Woodrow, 1996). There are several problems related to the process of evaluation with the primary being the lack of a good measurement tool to track changes in the educational outcome. This problem is also related to the fact that "learning" itself is a slippery term and defies universal definition, making the quantification and measurement of learning a tricky process. Indeed, without a robust definition it becomes particularly difficult to measure it.

It has been suggested that learning can be measured using other "surrogate" measuring techniques such as the evaluation of the changes in the *attitudes towards* learning and the changes in the learning *process*. Based on the examination of a series of assessment projects, Mitra and Hullett (1997) has suggested that attitudes towards technology can perform as an alternative way to measure the effectiveness of the introduction of technology in the learning place. This approach has been applied to various academic scenarios to report on the ways in which technology continues to impact the process of teaching and learning (see, e.g., Lawson and Pelzer, 1999; McQueen and Fleck, 1999; Merisotis and Phipps, 1999; Mitra, et. al., in press; Mitra, et. al., 2000; Mitra, et. al., 1999; Mitra and Hazen, 1999; Mitra, 1998; Phipps and Merisotis, 1999). However, what has still remained a challenge is trying to find a particularly robust set of measures that would address all the different aspects of the effects of technology in teaching. Woodrow (1991) reported on the analysis of four different attitude scales and all of them tended to measure different attributes of the outcome of the application of technology in teaching. Furthermore, with the changes in technology some of the specific aspects of the measurement continue to change as well, thus making some of the scales inappropriate for the current mode of technology intervention.

In this paper it is suggested that it is possible to identify some specific aspects of the outcome of the technology use in teaching where the factors being measured are not necessarily technologically determined. In stead, the factors being measured are more fundamental constructs of the human-technology interaction in the educational setting and thus can be applied more broadly to several different assessment situations and can be more universally applied. Using the data from an ongoing longitudinal study of the application of technology in an American private liberal arts institution, it is possible to show that there are certain fundamental aspects of the effects of the application of technology that can be measured using reliable attitude items.

Methodology and Data

This paper utilizes the data from a longitudinal study to assess the impact of technology introduction in liberal arts education at a non-technical small private university in the United States. The data was collected over four academic years and this *post hoc* analysis uses the data collected in the spring of 1999 from a sample of students who responded to a questionnaire mailed to them. The questionnaire was developed by conducting a series of focus group meetings that explored the various technology-related issues that the students were facing with the universal and standardized introduction of technology in teaching. The questionnaire included nearly fifty attitude items measured on a five-point Lickert-type scale. Of these fifty, there were several items that were specific to the local conditions of the university. The remaining items have been analyzed here. The entire questionnaire also consisted of usage questions and demographic questions.

Analysis and Results

The analysis included two components: first, a factor analysis that elicited four factors on the basis of twenty-five items that were selected as the general attitude items in the questionnaire and second, the items that loaded on the same factor were subject to reliability tests (Cronbach's alpha) to explore the levels of reliability of the similar items.

The 25 items were analyzed using a varimax rotation and this resulted in four major factor loadings. These are reported in the next table.

Table 1: Factor loadings

Factor 1	Loading
1. Talking face-to-face with professors is generally gratifying	.984
2. Computers enable me to interact more with professors	.488
3. The use of computers positively impacts the social life	.976
4. The use of computers makes the academic climate of Wake Forest intellectually exciting	.984
5. The use of computers is increasing cooperative learning at WFU	.749
6. Computer mediated communication makes it easy to maintain relationships	.982
7. Computers provide a non-threatening way to communicate	.628
8. Computers allow me to communicate with people I would not normally be able to communicate with	.921
9. When communicating using a computer one does not need to be formal	.976
10. The use of computers is strengthening the academic climate	.983
Factor 2	
11. Computers are effective for communicating with other students about class related work	.824
12. Computers are effective for communicating with faculty about class related work	.888
13. Computers are effective for communicating with other students about non-course related subjects	.802
14. Computers are effective for communicating with faculty about non-course related topics	.691
15. Communicating with professors by e-mail is generally gratifying	.628
Factor 3	
16. I would stay away from classes that do not use computers	.920
17. The computerization process poses a threat to my privacy	.810
18. The adoption of computers will give more power to the instructors	.922
19. Computer use increases the usual college work load	.293
Factor 4	
20. There is a need for classes which teach "how to" use a computer	.142
21. I prefer classes in which I get to use computers	.502
22. Computer use helps me better understand the course material	.571
23. I prefer classes with "hands-on" computer experiences	.610

24. I expect that I will be required to use the computer	.616
25. I expect ALL instructors at Wake Forest will use the computer in teaching	.687

The factor analysis was followed by the computation of the inter-item reliability for the items within each of the factors. This correlation was high, with the Chronbach's alphas for the four factors reported in the next table.

Table 2: Alpha value for each factor

Factor Number	Alpha
1	.93
2	.81
3	.75
4	.36

While the alpha values reported in Table 2 are relatively high, a second set of alpha values were computed after dropping from the set the item with the lowest factor weight from each of the factors reported in Table 1. This resulted in higher alpha values and thus a more robust set of items. These adjusted alpha values are reported in the next table.

Table 3: Alpha values after dropping item with least weight

Factor Number	Alpha
1 (drop Item 2)	.96
2 (drop Item 15)	.81
3 (drop Item 19)	.81
4 (drop Item 20)	.51

These results suggest that it is possible to propose a computer attitude scale with 21 items which could serve as a surrogate measure for learning outcomes by providing an evaluation of the attitudes of students towards the use of computers in teaching. The items all could use a five-point Lickert type scale with '5' being 'strongly agree,' '4' being 'agree,' '3' being 'no opinion,' '2' being 'disagree,' and '1' being strongly disagree.' The items are now presented with slight alterations in the reference to a specific university so that the items can be used at any place of higher education.

Table 4: Attitude items

Talking face-to-face with professors is generally gratifying
The use of computers positively impacts the social life
The use of computers makes the academic climate of the university intellectually exciting
The use of computers is increasing cooperative learning at the university
Computer mediated communication makes it easy to maintain relationships
Computers provide a non-threatening way to communicate
Computers allow me to communicate with people I would not normally be able to communicate with
When communicating using a computer one does not need to be formal
The use of computers is strengthening the academic climate
Computers are effective for communicating with other students about class related work
Computers are effective for communicating with faculty about class related work
Computers are effective for communicating with other students about non-course related subjects
Computers are effective for communicating with faculty about non-course related topics
I would stay away from classes that do not use computers
The computerization process poses a threat to my privacy
The adoption of computers will give more power to the instructors
I prefer classes in which I get to use computers
Computer use helps me better understand the course material
I prefer classes with "hands-on" computer experiences

I expect that I will be required to use the computer
I expect ALL instructors will use the computer in teaching

Discussion

The analysis presented here first suggests that it is possible to develop standardized items that can be used to measure the attitude of students towards the introduction of computers in teaching. The items, by clustering around four factors, also represent specific attributes of the effects of computerization that can become yardsticks for the more urgent question of measuring the effectiveness of computers in enhancing learning. In presenting the findings from several different studies, Mitra and Hullett (1997) have indicated that "predsipositions" play an important role in the perception of the effectiveness of computer aided instruction. Within the notion of predisposition, the authors included issues such as comfort with computers, the rapidity of the introduction of computers and other such perceptual ideas. Additionally, the authors noted that technographics, context and technological sophistication could also play roles in the determination of effectiveness of computers in instruction.

The results of this study help to support the findings of Mitra and Hullet (1997), but also suggest that the idea of measuring predsipositions need to be made more elaborate and must include a large array of perceptual parameters. Indeed, some of these parameters are no longer only predsipositions but also include perceptions that develop as computer aided instruction becomes more prevalent on college campuses. In other words, the perceptions that can determine the effectiveness are not only the ones that the students possess as they are initiated to computer aided instruction, but the effectiveness could also depend on perceptions that develop with continued exposure to computer aided instruction. Indeed, the four factors identified here represent four major perceptual categories all of which arguably can have an impact on the perceived effectiveness of the computerization process. This is supported also by arguments made by authors such as Pacey (1983) and Negroponte (1995) who have suggested that the effectiveness of computers often depends on the way in which the users might perceive the values associated with the "practice" of using computers. Thus, by measuring the values and expectations related to computers in teaching, it might be possible to arrive at a more reliable measure of the effectiveness. The data from this study suggests that there are four key values that can be measured as represented in the four factors identified in the analysis.

The first parameter that needs to be measured can be called "climate of interaction." Clearly, the computer has become a key form of an interaction device for the students and the effectiveness of the computer as an interactive tool can have a large impact on the way in which the computer becomes effective in instruction. Consequently, by knowing how well the environment supports the interactive applications of the computer could have a lot to do with how students evaluate the effectiveness of the computer in education. Extrapolating from there, it is also possible to argue that if indeed the computer enhances interaction then it could begin to play a critical role in transforming the instructional environment. Thus it is important to measure the way in which students perceive the enhancements in interaction with the introduction of computers. Interestingly, this enhancement is not only with the use of computer mediated communication, but the very presence of the computer and the accompanying shifts in the climate of the institution can also affect the more traditional forms of communication such as "face-to-face" interactions. The data suggests that such attributes should also be measured to get a sense of the changes in the climate of interaction that follows the introduction of technology. Thus the following items could be used to measure the climate of interaction.

- Talking face-to-face with professors is generally gratifying
- The use of computers positively impacts the social life
- The use of computers makes the academic climate of the university intellectually exciting
- The use of computers is increasing cooperative learning at the university
- Computer mediated communication makes it easy to maintain relationships
- Computers provide a non-threatening way to communicate
- Computers allow me to communicate with people I would not normally be able to communicate with
- When communicating using a computer one does not need to be formal
- The use of computers is strengthening the academic climate

The second parameter that emerges as important is also related to communication and can be labeled, "communicative effectiveness." Unlike the earlier item which is broad-based and addresses issues related to the overall climate of an academic institution, this second factor includes attributes that focus primarily on the role of the computer in the pragmatic act of communicating. It can be argued that a change in the perception of the effectiveness of the computer in facilitating communication could have an impact on the learning outcome. Consequently, it is important to be able to measure how effective the computer is considered to be in communicating with various groups with whom students typically have to communicate in the course of their academic activities in college. The following items refer to the communicative effectiveness of the computer in education.

- Computers are effective for communicating with other students about class related work
- Computers are effective for communicating with faculty about class related work
- Computers are effective for communicating with other students about non-course related subjects
- Computers are effective for communicating with faculty about non-course related topics

The third parameter that is important to measure to obtain an evaluation of the computer in instruction can be called the "abstract expectations" of the students as they are placed in a computer aided instruction situation. It is clear that the promises of technology tend to alter what students can expect from the computer and the instructional situation that they are placed in. These expectations, and how well they are met, can have a direct impact on the way in which students react to the overall use of technology in instruction. There are many facets of these abstract expectation and they include expectations about the level of use of computers in learning; apprehensions about the loss of privacy and concerns about the increases in the power inequity between the teacher and the student. In many cases these might strictly be perceptions and the changes are not as dramatic as the students might think they are, but it is still important to measure these expectations because people with different expectations could easily have different assessments of the effectiveness of the computer in teaching (see, e.g., Mitra, et. al., 1999). Therefore, the following items can be used to measure the abstract expectations related to the introduction of computers in teaching.

- I would stay away from classes that do not use computers
- The computerization process poses a threat to my privacy
- The adoption of computers will give more power to the instructors
- I prefer classes in which I get to use computers

Following from the notion of abstract expectations, there is a fourth parameter that should also be measured to develop an assessment of the effectiveness of the computer in teaching. The fourth parameter can be called, "pragmatic expectations." These items also deal with the notion of the benefits and burdens of technology, but focus more on the specific ways in which students anticipate using the computer in the process of learning. Students entering a computer-enriched environment often come with specific expectations about what the computer could do to transform the learning process. If they perceive that there will be a positive transformation it is possible that their learning will be enhanced as well. Thus, it is important to measure what the students expect in terms of what the computer can do to transform their comprehension of the material being taught. This change is in turn related to the ways in which the students feel about the extent of their computer use with "hands on" application as well as the breadth of the computer use in terms of the number of classes in which they might be asked to use the computer. As pointed out in earlier research, these issues can impact the students' general assessment of the role and effectiveness of the computer in the practice of teaching. These items take the focus of attention away from a technologically determined, technology-centric view to a more sociologically determined focus on the practice of technology (Pacey, 1983). The following items attempt to measure this aspect of the pragmatic exceptions arising from the practice of using computers in teaching.

- Computer use helps me better understand the course material
- I prefer classes with "hands-on" computer experiences
- I expect that I will be required to use the computer
- I expect ALL instructors will use the computer in teaching

In summary, this paper and the data offers a valid and reliable measurement of four key parameters that can serve as indicators for the assessment of the effectiveness of computers in teaching. While these measurements offer an initial glimpse on the thorny question of measuring the effectiveness of computer assisted teaching, they do not, however, claim to be direct measurements of the teaching effectiveness. These items only offer alternative and surrogate measurements which, however, can be coupled with more direct measurements.

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