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Studying Computer Awareness

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Attitudes toward computers are considered a typical indicator of the relationship between humans and computers. There exists a standard measurement instrument: a computer attitudes test developed by Loyd & Gressard (1984a, 1984b, 1986), Loyd & Loyd (1985). It is widely used to study the attitudes of individuals, and groups and to relate attitudes toward computers to gender, age, and other factors (references above and Liao, 1995). The Loyd-Gressard test (L-G test) is a very good instrument, but its usefullness to a teacher in a computer oriented course is relatively minimal. Even if the teacher were to reach some conclusions about the current state of computer anxiety, computer confidence, computer liking and the assessment of computer usefulness among the prospective students as measured by the test, the assesment may not be enough to conduct a successful class. We can assume, for instance, that the class consists of a group of students who have a high degree of overall computer knowledge, but their attitudes are very negative. By the same token, the class may consist of students who have very positive attitudes, but no trace of understanding of what computers are about. Both situations require different pedagogy, but the L-G test may not be able to differentiate between them properly. It is also rather unclear how the L-G test could be used to help the teacher with the post-course assessment. Even if the pre- and post-course data were collected, the L-G test does not include an appropriate interpretative scheme. Desired data analysis would allow the teacher first, to assess the effects of the educational process and second, possibly to teach a better course the next time. Finally, it should be pointed out that positive attitudes do not need to lead to what everyone would consider a constructive computer-human relation. For example, consider a student who is fascinated by computer games. He may have a very positive attitude toward computers, but iit would be misleading to believe his attitude was based on the use of constuctive computer tools.

The aim of this paper is to introduce a new instrument which is currently being constructed and can be used by the teacher in the educational practice. We will concentrate on the methodological issues considered while developing it. We will introduce the current version of the instrument and specify the future work.

Human-Computer Relations -- How to Assess Them?

Let us start by observing how the human-human interactions are assessed. There seems to exist a very broad notion of *social well-roundedness* that is applied to a person when his/her relations with others are observed. There may be many definitions of this term and some disagreement as to what it means to be a well-rounded person. Intuitively this term involves a higher form of understanding of human-human interactions, awareness of the nature of inter-human relations and a set of proper attitudes represented through actions. In contrast to this broad approach, when the human-computer relations are being investigated, the attitudes toward computers are considered almost exclusively.

Since 1992 a new instrument is being developed which has as its goal the study of a broader area of human-computer interactions. The development of this instrument has proceeded through evolutionary stages where the results obtained through the data collection have been used to test and verify a number of sub-hypotheses. These result have led to adjustments to the instrument. These evolutionary changes led also to the changes in the overall goal of the instrument. Initially the basic categories studied were:

a. assessment of the role of computers in the society,
b. self-evaluation of frustrations and stress caused by the computer,
c. assessment of the role of the Computer Literacy course in reducing such frustrations,
d. elf-evaluation of the readiness for learning and openness for the new ideas.

The category a) relates to the "computer usefulness" studied in the L-G test, but their category was substantially broadened. The category b) encompasses the remaining three categories studied in the L-G test. Category c) was developed with the teacher in mind. Together with temporal changes in the results (the survey was to be applied pre- and post-instruction) the collected data was supposed to provide the teacher with the feed-back about the results of instruction. Finally the category d) was designed to assess the existence of a relation between students' attitudes toward learning and the attitudes toward computers (Paprzycki & Vidakovic 1994, Paprzycki, Vidakovic & Ubermanowicz, 1995)

The proposed instrument proved very inefficient when its domain of application has been extended culturally to the Polish universities. We have found out that the degree to which people have earlier experiences with computers (or just the exposure to the computers) has a very strong effect on the results. This discovery forced us to reexamine the existing instrument and introduce a number of changes. These changes were designed with a goal of obtaining a higher degree of universalization and consistency across nations and populations. We have also decided that a more general understanding of the relations between the subjects and computers should be tested. Our goal became to develop an instrument that would study the *computer well-roundedness* in the sense suggested by the *personal well-roundedness*. To achieve this goal we have decided to study two areas of human-computer interactions: attitudes toward computers and computer awareness. The assessment of attitudes was based on responses representing outlook on computerization, opinions about various facts, feelings related to these facts, and motivations for these feelings. Awareness is being studied through the reflexive nature of the responses which is visible through the level of analysis applied to various facts, judicious nature of decisions, and readiness for searching for the deeper meaning. The dynamics of attitudes and awareness is introduced as a function of time through a combination of changes in the factors studied. The proposed instrument, after being applied pre- and post-instruction, should allow the teacher to assess the following dimensions of the teaching process

- appropriateness of the level of instruction,
- the teaching style: knowledge delivery vs. knowledge construction,
- effect of group work vs. stimulating individual learning,
- level of stress among the beginners vs. the attractiveness of the course for the advanced students,
- providing self confidence among students vs. stimulating self reflection.

Creation of the New Instrument — Methodological Observations

Only a short summary of selected issues we have encountered while developing the new version of the instrument is presented here (a more extensive discussion is available in Ubermanowicz & Paprzycki (in press)).

The instrument is a modified 7-point Likert-type self-assessment test consisting of 28 statements (plus one statement inquiring about the earlier contact with computers). For the assessment of attitudes a monotonic scale is being used, while in the study of awareness a combination of monotonic and non-monotonic scales is proposed (see below). To be able to perform cross-cultural comparisons, the analysis of results is based primarily on differences between the pre- and post-instruction results. The unified structure of the instrument will allow to:

1. analyze responses to individual statements,
2. perform comparative analysis between control pairs of statements,
3. analyze groups of questions concentrated on a particular variable,
4. study temporal correlation between responses,
5. create a unified picture involving all the questions.

The current version of the instrument is a result of a series of evolutionary adjustments. In optimizing the instrument we have concentrated our attention on the following factors: a) spatio-temporal expansion, b) semantical harmonization, c) unification of probing, d) justification of estimators, e) quantization of monotonicity.

To illustrate each of these techniques, examples of the current statements will be used (against the background of inappropriate statements from the earlier versions of the survey).

Spatio-temporal Expansion

In the proposed method of interpreting the data it is extremely important to specify the statements in such a way that the same instrument can be used at the pre- as at the post-course testing. To allow this, appropriate tenses need to be used (e.g. we cannot use a future tense). In addition, the (usually methodologically appropriate) randomization of the order of statements between the pre- and post-testing is inappropriate.

The testing method is based on the study of internalized beliefs so the statements must be specified in such a way that they will illustrate them. Since the tested subjects have extremely different levels of earlier experiences with computers, the statements must be spatially broad — generalized to the external (non-computer-related knowledge). Since some of the respondents may be communicating with computers in their native language and some not, it is important that the statements be devoted to the representation of understanding with no emphasis on the knowledge of

the arcane terminology (this is especially important for the pre-test).

To study the temporal dimension of the test, statements have been combined in control pairs. For instance, to probe if the effect is temporary or long term, we can study the responses to the following two statements:

I know how to deal with a computer,

I am confident that I will be successful in working with computers.

Let us observe that the interrelation between the responses combined with the temporal change implies a robust set of interpretative indicators. Another example of how we can probe if the effect is local or global is represented by the following pair:

I would like to learn a lot more about computers,

I am always ready to learn difficult things.

Here the spatial aspect of attitudes (the relation between the attitude toward learning the particular subject and the global motivation toward learning) is studied. In addition to the above mentioned pairs (statements 3 & 5, 12 & 13), we have identified the following control pairs:

- statements 0 & 2 -- previous experience vs. positive experience,
- statements 26 & 27-- worrying about all people being enslaved vs. being worried about ones own addiction (level of internalization of the problem).

Semantic Harmonization

Singular statements in the survey must be harmonized with all other statements and in such a way that the responses that the subject makes to any single statement cannot lead to confusion when any other statement is considered. Let us observe the dissonance between the following pair of statements:

I have a negative attitude toward computers,

This course will help me improve my attitude toward computers.

Separately each one of these statements makes perfect sense but together they create a problem. If, in the first case, a student responds that she has a positive attitude toward computers, then it is unclear how should she respond to the second statement. If she expects a positive outcome from the course then she would like to answer the question positively, but since she already has a positive attitude toward computers, logic suggests the negative response. Such a dissonance may lead to serious problems with statistical interpretation of the data.

It is extremely important to use simple statements. The following unfortunate statement has been removed from the survey:

In the past I needed a use computer but I did not know how to use it.

It became unclear if the negative/positive response is related to the fact that the student "needed a computer" or "did not know how to use it."

Here are two more examples how slight modifications of the statements have improved the probing quality of the statement:

Using computers is possible only after an initial instruction,

Using computers is possible only after a minimal instruction.

The first statement is so obvious that was usually answered "yes" and provided with no information about the respondent. The modified statement probes the important question of "beginnings."

I am at a loss when starting to work with a computer

I am at a loss when I sit down to work with a computer

Here the first statement may indicate that what we are interested is the initial contact with computers, while the second statement clearly addresses the permanent state of stress related to the work with a computer. It is the latter state that we were interested in probing.

Unification of Probing

It is clear that we are probing variables that are continuous in the studied region. At the same time the Likert-type scale discretizes the possible responses. The empirical verification led us to the following modified 7-point Likert-type scale: a) ABSOLUTELY NO, b) NO, c) MAYBE NO, d) NO OPINION, e) MAYBE YES, f) YES, g) ABSOLUTELY YES.

The usage of the modifier ABSOLUTELY prevents some of the respondents from selecting the positive response when at least a minimal doubt exists. The modifier MAYBE helps respondents in the situation when the decision is very difficult by giving them an option of moving away from the lack of opinion. Overall, the selected scale gives the respondents a greater freedom of choice. These features are very helpful when the interpretation is based on studying temporal differences between responses and when a very sensitive tool needs to be applied.

Justification of Estimators

Since the method is based on the study of temporal fluctuation of responses, it is extremely important that the statements will be appropriately polarized. To achieve this we try to select the expected values of responses in such a way as to prevent the post-instruction values from "falling-off the scale." An example of a statement that was affected by such a problem was:

Computers will help me save time.

We have observed that in the pre-test, most of the responses were positive. There was no room for a possible positive change generated by the course. To avoid this type of problem two basic strategies were used. For the questions where we have expected that the temporal change can move the responses in both directions, we attempt at setting the expected initial response around the center; for instance:

I am aware of dangers caused by computerization.

In case when we expect a specific trend in the initial responses, the statement is modified in such a way to move the initial response off-center; for instance:

I have positive experience in working with computers.

Here the word "positive" is used to leave more room for an expected "improvement" caused by the course.

Special care is being taken to seminormalize the density distributions (to avoid the responses being concentrated heavily around one option). For instance, instead of an initial statement:

I am ready to learn new things,

which was usually accepted by the respondents the following sentence was used:

I am always ready to learn difficult things.

Statistical verification of the effects of the changes discussed above (and other similar) proved that they have substantially improved the reliability of the instrument.

Quantization of Monotonicity

Standard techniques based on making approximately 50% of the statements polarized positively and the remaining statements polarized negatively is being applied. Negations and double negations have been removed as they have been verified to lead to confusion among the respondents. When the attitudes are tested, the monotonic polarization (scale 1, 1.5, 2, 2.5, 3, 4, 5 for the positively polarized questions and its reverse for the negatively polarized questions) of responses is being used.

One of the important open problems remains the establishment of polarization of the responses reflecting computer awareness. Here the monotonicity of the scale was partially rejected. The typical reason for such a decision can be illustrated by analyzing the following statement:

One day computers will enslave people.

The computerization leads to possible gains but also generates problems. It can be suggested that the response ABSOLUTELY NO means that the respondent does not have an appropriate knowledge about the dangers of computerization and should be graded relatively low. Answers NO and MAYBE NO may be graded relatively high as the indicators of respondents' awareness of the possible problems generated by computerization. The lack of opinion could be graded higher than the response ABSOLUTELY NO, as the statement itself is highly problematic, and it may be assumed that the lack of opinion reflects recognition of multi-dimensionality of the problem. It is possible to argue that the positive responses may be graded low as they indicate low self esteem and fear of computers (and fear can be treated as an indicator of low levels of computer awareness -- we fear things that we do not understand). This could suggest a scale 2.5, 4, 5, 3, 2, 1.5, 1. This assessment may seem very controversial. We are currently in the process of collecting opinion of a group of experts to establish the proper polarization and scaling of the statements related to the awareness component. The initial responses led us to believe that for statements 19, 20, 26 and 27 a non-monotonic polarization should be applied.

Overall, for each respondent, a geometric mean of responses is calculated. This form of data analysis allows us partially to avoid the problem of incongruent responses. The results collected recently (1380 surveys) show the distributions close to normal, and the consistency tests suggest that we can apply the statistical methods designed for this distribution (see Table 1).

Table 1

	AWARENESS	ATTITUDE
K-S Test	d=0.0979, p<0.01	d=0.0473 p<0.01
Lilliefors Test	p<0.01	p<0.01
Shapiro-Wilks Test	W=0.9647, p<0.00	W=0.98 p<0.00

Verification

The optimization and verification of the instrument has been taking place since the Fall 1994 semester. So far, 8 statements have been completely rejected, 12 new statements have been introduced and tested, 9 statements have been completely modified, and 7 have been adjusted. Some of the reasons for statement rejection have been specified above. Additionally we rejected the statement:

In the future the role of computers will increase, as some of the respondents scribbled in the word: UNFORTUNATELY. This showed to us that a positive response to this statement may indicate a very negative attitude toward computers.

Out of the rejected statements only some of them were part of the original questionnaire. In addition, some of the new statements have been rejected as having no selective power, for instance:

I will use computers after graduation.

There was no statistically significant change observed between pre- and post-course results in any of the response groups studied. The current version of the survey is presented in the Appendix.

The evolutionary verification-modification process has been successful. The next to the last version of the instrument has reached the alpha-reliability of 0.78. The preliminary results based on the current version of the survey (based on 720 High School surveys and 660 University surveys collected in Poland in October, 1995) suggests the reliability is reaching 0.84. The same data suggests that further improvements in the instrument are necessary. We have found that responses to statement 10 do not correlate with responses to any other statement (this statement will be replaced). Statement 22 has generated confusion and will need to be adjusted.

Practical Application

Our results indicate that the instrument may have practical usability for the educators. The assessment is based on the comparison between the pre- and post-instruction results and can be applied only inside a particular group of students -- taught by one teacher. As specified above, the following dimensions of pedagogy can be analyzed (the details are being currently developed):

1. The correlation between the level on which the course was delivered and the level of student' preparation In case of a large difference between these two levels, the dispersion of the self assessment estimators (statements 3, 5, 6, 9, 11, 12, 15) has been observed. When the course has reached students, these estimators tended to group together,
2. The teaching style (difference between knowledge delivery and knowledge construction) and the assessment is based on the changes in responses to statements 4, 5 and 26 related to the responses in the group 6, 9, 27
3. Effects of group work vs. stimulation of individual learning can be assessed by comparing the changes in the responses to statements 2, 3 and 10 and comparing them with responses to statements 7, 8, and 12,
4. Level of stress among the beginners vs. attractiveness of the course for the advanced students is reflected in changes in the responses to statements 1, 11 and 16 matched with the responses to statements 13, 17 and 24
5. Propagating self confidence among students vs. stimulating self reflection is assessed through temporal changes in the statements 18, 19, 20 and compared to the changes in the group 21, 25 and 28.

Conclusion

We have presented a new instrument that can be used by the educators to study students' attitudes toward computer and computer awareness. This instrument is a result of a process of evolutionary improvement and has reached high reliability. We are currently in the process of verifying the computer awareness scale and would like to invite all interested individuals to join our effort as experts. We are also preparing the interpretation template that will be useful for teachers to assess the results of the pedagogical process. We would like to invite all parties interested in trying out our instrument to contact us at the address below.

Appendix

Current version of the instrument

0. I have used computers in the past
1. My feelings toward computerization are negative
2. I have positive experience in working with computers
3. I know how to deal with a computer
4. I am at a loss when I sit down to work with a computer
5. I am confident I will be successful in working with computers
6. Only people with a knack for computers use them
7. It is possible to use computers only after a minimal instruction
8. One can acquire basic computer skills by oneself
9. I would be afraid to be left alone with a computer
10. I like to study together with someone who knows more than I do
11. I feel uncomfortable when others know more about computers
12. I am always ready to learn difficult things
13. I would like to learn more about computers
14. Computers should be used in all courses
15. I am convinced that computers are useful in my field
16. I doubt the usefulness of computer courses like this one
17. Even students who know computers can get something useful out of this course
18. Already today I know in what areas computers are irreplaceable
19. Computers can help one deal with everyday life problems
20. Computers prevents users from making mistakes
21. Working with computers requires high concentration
22. Computers force faster thinking
23. In the future computers will help me save time
24. I want to spend more time working with computers
25. Extended work on a computer is bad for one's health
26. One day computers will enslave humans
27. I am afraid I can get addicted to computers
28. I am aware of the dangers caused by computerization

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