Canadian Journal of Learning and Technology
Volume 29(1) Winter / hiver, 2003

Human-Computer Interaction: A Review of the Research on its Affective and Social Aspects

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Abstract

Prevailing research influenced by cognitive psychology has dealt mainly with the cognitive aspects of the human-computer interaction (HCI). The advent of computers in schools should prompt educational researchers to scrutinize the affective and social aspects of student-computer interactions since they play an important role in learning. A review of 34 qualitative and non-qualitative studies was conducted. Its main purpose is to synthesize results and to highlight important issues that research has left unsolved. Results concern the nature of the HCI (social or parasocial), the interface (mainly a comparison between graphic and text types), and the relation between variables linked to HCI (mainly trust, locus of control, attitude, ease of use, and liking).

Résumé

Influencée par la psychologie cognitive, la recherche sur les interactions personne-ordinateur a porté jusqu'à présent sur les aspects cognitifs de ces interactions. La présence de plus en plus grande de l'ordinateur à l'école devrait amener les chercheurs en éducation à s'intéresser aux aspects affectifs et sociaux des interactions étudiant-ordinateur, car ces aspects jouent un rôle important dans l'apprentissage. Une recension de 34 études quantitatives et non quantitatives permet d'en dégager les principaux résultats et de mettre en évidence des pistes de recherche. Les résultats

concernent la nature de l'interaction personne-ordinateur (sociale ou parasociale), l'interface (principalement une comparaison d'interfaces de type graphique ou texte) et la relation entre des variables liées à l'interaction personne-ordinateur (principalement la confiance, le lieu de contrôle, l'attitude, la facilité d'utilisation et l'appréciation de l'usager).

Introduction

The advent of computers in schools has diversified the types of educational communication. Students still have interpersonal interactions with teachers, but they also have many computer-mediated communications: communications with people through computer (using e-mail, for instance) and communication with the computer itself. The latter has given rise to an important field of study known as Human-Computer Interaction (HCI). HCI is " a discipline concerned with the design, evaluation, and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them." (ACM SIGCHI, 1996, p. 5).

Research on HCI, influenced by cognitive psychology, has dealt mainly with the cognitive aspects of the human-computer interaction (e.g., the work of Card, Moran, and Newell, 1983). Lewis (1990) describes such research as "models individual cognition in isolation from social and other environmental influences" (pp. 128-129). The academic work of Preece, Rogers, Sharp, Benyon, Holland, and Carey (1994) supports the importance attached to cognitive sciences in the study of HCI, whereas the social aspect of interactions, both the interpersonal interaction established through the computer and the human-computer interaction, is discussed in only a few pages of the document.

Mangold (1997) notes that there re-direction in the perspective of ergonomic software research moving from a tool-use oriented approach towards a communication-oriented approach. He contends this implies that research should focus on affective-emotional states and on process aspects of users.

Many reasons should prompt educational researchers to scrutinize the affective and social aspects of student-computer interactions. First, in educational settings, where children and adolescents are concerned, the importance of these aspects of communication is increasing. The development of one's identity and self-esteem is an important process, which occurs during childhood and adolescence, and communication is one of means by which these concepts are developed. Second, the social aspect of learning is even more present when technologies are used because the scarcity of equipment leads teachers to use group learning: most of the time, at least two students work at the same computer. Third, Vygotsky's approach to human cognition, brought forward during the last decades, has put emphasis on the social aspect of learning and, consequently, on phenomena such as distributed cognition over people (Salomon, 1993) or over humans and machines (Dillenbourg, 1996).

Even though there are large numbers of studies on HCI, the affective and social aspects

are still neglected. And since few studies have explored the area of student-computer interaction (SCI), very little is known about the affective and social aspects of SCI. The following review was conducted on the broader area of human-computer interactions, with no regard to the specific settings involved.

Purposes and Limits

The purposes of the following review is to integrate knowledge from diversified angles of research and to highlight important issues that research has left unsolved with respect to the domain of education. Limitations are significant. The following reviews only the most important aspects of the studies analyzed due to the vast area of research considered; as a result complete definitions of variables are not presented.

Method

The following section presents the collection of studies as well as the method of analysis.

Selection Procedure and Collection of Studies

Five databases were consulted over a period of ten years (1988-1999) which included: Educational Resources Information Center (ERIC), Dissertation Abstracts, Sociological Abstracts, Psychological Abstracts, and FRANCIS. The three sets of descriptors used for these computer queries were: human-computer (and its synonyms), interaction or relation, and affective or social aspects (and their synonyms). The words or phrases used depended on the database consulted. Only empirical studies were retained. Furthermore, the object of the study itself, that is, the human-computer interaction, led to the selection of those studies which specifically involved subjects in interaction with computers. For this reason, research on the individual's attitude towards computers, for example, was excluded. In the case of reports or theses comprising several studies or parts, only those concerning the affective or social dimensions of human-computer interaction were considered. This international bibliographic search yielded 34 studies from different countries (United States, United Kingdom, Korea, France, and Canada), which included 24 using a quantitative method, and ten using a non-quantitative method (see Table 1). The expression "non-quantitative" is preferred to "qualitative research" because some research designs, such as evaluative research or research and development (R&D), cannot necessarily be considered as qualitative. Denzin and Lincoln (1994) define qualitative research as a, "multimethod in focus, involving an interpretative, naturalistic approach to its subject matter." (p.2).

Table 1. *Overall View of Studies*

Authors	Date	Location	Type		TP	Subjects		Purpose	
			QT	QL		F	M	E	NE
Corston and Colman	1996	UK	x		P	36	36		x
De Laere et al.	1998	USA	x		P	78	80		x
Hall and Cooper	1991	USA	x		S	36	27		x
Hanson	1990	USA	x		P	36*			x
Hawk	1989	USA	x		P	85*			x
Jones and McCormac (study 1)	1992	UK	x		P	61*			x
Jones and McCormac (study 2)	1992	UK	x		P	61*			x
Kim and Moon (study 3)	1998	Korea	x		P	123*			x
Kim and Moon (study 4)	1998	Korea	x		P	2	53		x
Lee and Moray	1992	USA	x		P	16*			x
Lerch et al. (study 1)	1997	USA	x		P	92*			x
Lerch et al. (study 3)	1997	USA	x		P	67*			x
Lerch et al. (study 4)	1997	USA	x		P	63*			x
Meunier	1995-96	USA	x		P	30	30	x	
Muir and Moray (study 1)	1996	CND-FR	x		P		6		x
Muir and Moray (study 2)	1996	CND-FR	x		P		6		x
Robinson-Staveley and Cooper (study 1)	1990	USA	x		P	40	40		x
Robinson-Staveley and Cooper (study 2)	1990	USA	x		P	40	40		x
Rosenthal	1990	USA	x		P	99	146		
Song	1990	USA	x		P	20*		x	
Sproul, et al.	1991	USA	x		P	72	58		x
Sundar	1994	USA	x		P	30			x
Tsai	1991	USA	x		C	90	132	x	
Wenger	1991	USA	x		P & C	20*			x
Cernushi-Salkoff	1990	France		x	S	70*		x	
Hugues, Morris, and Plant	1993	UK		x	NS	2	18		x
Lynch	1990	USA		x	P	5 groups*		x	
Norman and Thomas	1991	UK		x	S	6*			x
Novick	1988	USA		x	L	2 dyads*			x
Orleans and Walters	1996	USA		x	S & P		12		x
Pritchard et al.	1989	USA		x	NS	213 CBTS		x	
Robson and Crellin	1989	UK		x	P	2*			x
Sesko	1993	USA		x	NS	1	3	x	
Woolgar	1991	UK		x	S	2	2		x

Legend:

* Gender not specified	CND-FR: Canada/France	TP: Theoretical Perspective	E: Educational
F: Female	QT: Quantitative	P: Psychology	NE: Non Educational
M: Male	QL: Qualitative	S: Sociology	L: Linguistics
CBTS: Computer-base Training Software		NS: Not Specified	C: Communication

Analysis Procedure

Inspired by the work of Cooper (1982) on integrative reviews of quantitative studies and by Noblit and Hare's (1988) synthesis of qualitative research, a grid divided into nine areas was used. The authors of each study, the date of publication, the geographical location,

the object, the conceptual framework (including the variables or concepts), the number of subjects and setting, the method, the results, and further research directions were compiled. In addition, the studies were grouped according to the method used: quantitative or non-quantitative.

Results

The following section reviews the findings of the studies analyzed, giving information on theoretical perspectives, purposes, and methods used. In presenting the findings, quantitative and non-quantitative studies are distinguished.

Quantitative Studies

The following studies pertain to the nature of human-computer communication, the effect of variables on the human-computer interaction, as well as interfaces used in interaction.

Nature of the human-computer interaction. Sundar's (1994) study examines the parasocial nature (as in human television interaction) or the social nature (as human-human interaction) of the human-computer interaction. In his opinion, human-computer interaction is social (users tend to treat computers as though they were other human beings) and not parasocial (users tend to covertly interact with imagined others through the computer terminals like they do with mass media characters). Thirty undergraduate students participated in the experiment. A 76-item questionnaire with five indices measuring socialness was used to collect data. No theoretical framework was specified, nor was factor analysis conducted on the questionnaire to assess its structure. A 2 x 2 design (computer or programmer and praise or criticism) was used. Subjects were randomly assigned to the computer or programmer condition (15 subjects each). The praise or criticism condition is a within-subject factor (one session each). Results show that when facing the same type of interface, subjects who were told that they were interacting with a computer had a more positive response than those who thought they were interacting with a programmer. A sign test yielded 101 of the 112 variables that were below 0.4 significance level (0.5 is the maximum possible) to be in the hypothesized direction ($p < .0001$). According to the author, if this type of communication were parasocial, the subjects would have had the same expectations. Using a one-tailed t-test, it was found that the hypothesis "Human-computer interaction is social and not parasocial" was supported by the fact that differences between the computer and the programmer conditions for 50 of the 148 dependent measures were significant at the .01 level (31 dependent measures at .05). This hypothesis is supported regardless of the content of the interaction, since the praise-criticism condition did not yield to any significant differences.

Wenger (1991) looks into the rhetorical contract in human-computer interaction by measuring the effect of errors messages (consistent or inconsistent) and of the interface used, either MAC (direct manipulation interface) or DOS type (command interface), on users' affective response across four tasks. Therefore, the design is a 2 (between) X 2 (between) X 4 (within) three-way factorial design. Wenger (1991) examines the concept of social expectancy (the expectation of appropriate interactions as it develops when people

use a computer interface). The dependent variables measure user's rating of the system, of himself, and of his sense of control as measured by three short questionnaires after each of the four tasks to be executed during the experiment. The complex patterns of result[1] obtained from 20 first-year psychology students indicate that the direct manipulation interface seem to establish more social expectations than command interface. Moreover, users of the direct manipulation interface who experience inconsistent error message expressed intense negative affective responses.

Hanson (1990) examines the effect of experience with computers on aspects of social interaction in terms of thinking and feeling as well as the mediating effect of corresponding properties of thinking and feeling about interacting with computers. The study is grounded in concepts of occupational socialization mainly from the works of Berger and Luckmann (1967)[2] and Scott, Osgood and Peterson (1979) studies of cognitive structure. Thirty-six professional programmers at a large company participated in the study. This study dealing with individual's socialization used a correlational design, putting programmers' computing experience (long-term/short-term) in relation with affective properties (liking and extremity of liking) and cognitive properties (abstract integration and cognitive differentiation). Measures included two sets of questions, one questionnaire which elicited information on experience, background, demographic information, and index of overall psychological well being as well as a questionnaire used to identify cognitive and affective properties of interaction profiles. As anticipated, long-term users like their interactions with people less than their colleagues with fewer years of experience ($\beta = -.40$, $p < .05$). The effect of long-term computing experience on the level of liking people interaction is mediated by the extent to which users (programmers) like computer interactions ($\beta = -.40$, $p < .05$). As expected, within the domain of computer interactions, the effects of recent and long-term computing experience on the level of extremity of liking computer interaction is mediated by the level of cognitive differentiation ($\beta = -.58$, $p < .05$ and $\beta = .36$, $p < .15$, respectively), that is to say the extent to which the events and attributes are distinguished from another by an individual. However, contrary to the proposed hypothesis, the long-term experience users tend to like their interactions with computing systems less than their colleagues with fewer years of experiences ($\beta = .30$, $p < .10$). Furthermore, contrary to the hypothesis, advanced, long-term experience programmers have higher levels of extremity of liking in both areas: interaction with computers and interaction with people ($\beta = .38$, $p < .05$ and $\beta = .54$, $p < .05$, respectively). Finally, Hanson's results (1990) show that the level of extremity of liking computer interactions mediates the effect of computing experience on the level of extremity of liking people interaction ($\beta = -.65$, $p < .05$ and $\beta = .54$, $p < .05$, respectively). Globally, the results show that users acquire modes of thinking and feeling in their interactions with computers and that these modes can transfer to interactions with people under some conditions.

Variables related to human-computer interaction. Hall and Cooper's (1991) study relates gender, type of experience with computers (successful or unsuccessful), and length of experience (low, middle, or high) to attributions (tool-like or human-like reference) by

means of a casual comparative design. There is no reference to a particular theoretical framework. Thirty-six females and 27 males college students from an English composition class participated in the study. Measures included two self-reports using a computer: one describing a successful experience and another one describing an unsuccessful experience. Two raters assigned an overall rating on a 5-point scale (1= human and 5 = mechanical) to the subject's style of interaction with the computer as evidenced by the two self-reports. Using a 2 x 3 repeated measures ANOVA, results indicated that successful episodes while working on a computer were more often reported using impersonal references to the computer (objective and instrumental terms) ($F(1,55) = 18.94$, $p < .0001$). Moreover, they demonstrate that females made tool-like references more often than males ($F(1,55) = 4.92$, $p < .03$), and only females view the computer more as a tool as their experience increases ($F(2, 55) = 4.54$, $p < .01$).

Meunier's causal comparative design study (1995-1996) examines the effects of gender, personality - based on Jungian's psychological types (males only, females only, mixed), on learning, keyboard control, and verbal interaction. She also examines the effect of dyad type on learning and the effects of keyboard control and verbal interaction on learning. Data indicate that females and males focus on different types of information: females learn significantly more vocabulary concerning story characters (mean difference = 6.73, $t = 2.34$; $p = .02$)[3] . Males or females are affected by the type of dyad. Personality has a stronger effect than gender on learning ($F = 3.26$, $p = .02$). Personality, defined in terms of four psychological traits, is a stronger predictor of language learning and keyboard control (which member of the dyad is keyboarding) than gender. Keyboard control has a negative effect on learning ($p = .01$)[4] .

Two studies deal with the social facilitation effect. Corston and Colman (1996) examined the effects of gender and social facilitation based on Zajonc's drive theory of social facilitation on computer performance and attitudes toward computers and computer users. A sample comprising of 36 males and 36 female undergraduate students from a wide range of study areas participated. The randomized group design included six treatment conditions: female and male alone (gr. 1 and 2); females and males with the same-sex audience (gr. 3 and 4); females and males with opposite-sex audience (gr. 5 and 6). The treatment consisted of five sixty-second trials where subjects were required to use a small mouse to maintain a small white cross in the centre of a same-size moving white square. Questionnaires prepared for the experiment (the last two items adapted from Collins' questionnaire) collected the following types of information: sex and age, self-rated level of computer usage, self-rated level of computer competence, self-rated level of computer-related anxiety, attitudes towards computers and types of people whom subjects perceived to be computer users. As expected, this study confirms both gender effect and social facilitation effect: male subjects performed significantly better than female subjects on a computer-based task and subjects performed significantly better in the presence of an audience alone ($F(2,66) = 3.37$, $p < .05$; effect size $n^2 = .09$). There are also gender differences related to attitude towards computers and computer users. A higher proportion

of males than females think that computers are easy to use (χ^2 (1) = 9.45, p < .01). A higher proportion of males than females think that people who like computers are often not very sociable (χ^2 (1) = 4.18, p < .05). Finally, a higher proportion of females than males think that it is difficult to go if you don't understand computers (χ^2(1) = 8.04, p < .01). Robinson-Stavely and Cooper (1990) report on two casual comparative studies based on Zajonc's (1965) theory of social facilitation and Maccoby and Jacklin's (1974) research on gender differences also verified the effects of the presence of another person on variables different from those of the previous study: the performance, attitude, and anxiety of an individual interacting with a computer. The attitude measure used takes into account the attitude towards the task and towards the computer in general. Eighty undergraduate students containing 40 males and 40 females played a computer game "ZORK". Each subject works alone or with a stranger of the same sex for two 15-minute periods. Three questionnaires were used before, between, and after the periods, which collected data on previous computer experience, current level of anxiety, general level of anxiety for (study 1), attitude toward the task (study 2), and attitudes towards computers in general (study 1). The results show that women having little computing experience did not perform as well as men in the same category, they had a more negative attitude, and suffered higher anxiety than their male counterparts (F(1,72) = 6.89, p < .01). There was no gender difference in high experience subjects. The same authors investigated the effect of expectancy of success. Compared with negative expectancy subjects, those with positive expectancy had a better performance, a lower level of anxiety, and a more positive attitude (F(1,56) = 7.44, p < .01). The authors found no gender-based differences.

Based on the concept of locus of control found in Rotter's Social learning theory (1966) revised by Valecha, Ostrom, Baroudi and Orlikowski (1988) concept of user attitude and the author's concept of user involvement, Hawk's (1989) study examines the moderating effect of locus of control on the relationship between involvement and user attitude toward information systems used at work. The sample comprised 85 users of 48 based information systems from 18 organizations, occupying functions from clerical workers to top manager. User involvement was measured using a scale developed for this study (Cronbach's alpha = 0.84) whereas a measure of user attitude was obtained by the short form measure of user satisfaction (Baroudi and Orlikowski, 1988). Locus of control was measured by Rotter's (1966) scale, as revised by Valecha and Ostrom (1974). The user involvement measure was administered to the manager and the two other measures where administered to the users. User involvement is a more powerful predictor of user attitude (β = -13.41, p < .05) than locus of control (β = -3.23, p < .05). However, locus of control influences the relationship between user involvement and user attitude (β = 1, p < .05). The results of an analysis breaking down subjects under high and low user involvement indicated that external-control users who are not highly involved have a less positive attitude towards the usefulness of the computer. The opposite hypothesis is not supported.

Grounded in the theoretical model of computer-mediated work behaviour based on Milgrim's obedience paradigm (1994), Rosenthal's (1990) study examines the effect of

variables such as authoritarianism, attitude, locus of control, gender, and computer literacy on compliance to computer-mediated commands in the context of a decision-making simulation. Using school management classes stimulating a credit analysis, 248 students enrolled volunteered for the study. The experimental manipulation was a credit analysis simulation in which there were: two sources of authority, many opportunities for compliance, and a relevant situation that approximated a real world job in laboratory settings. Only four of the nine hypotheses were confirmed. As expected, subjects demonstrated significant levels of compliance with computer-mediated commands ($Q(4) = 196.7$, $p < .001$), even in the presence of a competing source of authority ($Q(4) = 49.757$, $p < .001$). Individuals with a more positive attitude towards computers demonstrate a lower degree of compliance ($F(1,63) = 7.66$, $p < .01$ for females; $F(1,81) = 7.44$, $p > .05$ for males), but this effect is moderated by gender as indicated by the difference between the F statistics. Individuals who rate themselves higher in computer literacy will demonstrate less compliance, but this effect is again moderated by gender ($F(1,63) = 4.45$, $p < .05$ for females; $F(1,81) = .31$, $p > .05$ for males).

Six studies focus on the trust variable. Muir and Moray's studies (1996) are grounded in Muir's model of trust in machines based upon Barber's (1983) taxonomy of the three meanings of trust in interpersonal relationships and the model of dynamics of interpersonal trust of Rempel, Holmes, and Zanna (1985). Using six male graduate students whose experimental task was to operate an automatic pump or three-way valve, Muir and Moray's studies (1996) addressed the following three questions:

1. Are operators able to make subjective ratings of their trust in automation?
2. How do properties of the automation affect the operators' trust in automation (in study 1)?
3. How do properties of the automation affect the operators' trust in automation and intervention behaviour (in study 2)?

According to the results of study 1, operators were able to make subjective ratings of their trust. Operators' overall trust in automation was affected both by display ($F(2,10) = 7.37$, $p< .01$) and control properties ($F(6,30) = 2.43$, $p < .05$), whatever the types of control errors (no error, constant proportional error, and variable error)[5] . Both competence (pumps perform properly) and responsibility of the automatic system (pumps performs the task designed to do) accounted for a high proportion of the variance in overall trust (respectively, 81%, 76%). The stepwise predictor selection method with predictability, dependability and faith as candidate predictors shows how trust develops over time. Trust is at first best predicted by predictability ($R^2 = .63$), after a while by dependability ($R^2 = .99$), and finally by faith ($R^2 = .78$). However, due to a high degree of multicollinearity between the predictors, these results must be interpreted cautiously. Study 2 shows that magnitude ($F(4,20) = 31.99$, $p < .001$) of the control error influenced operators' trust and that variability has only a marginal effect ($F(4,20) = 2.58$, $p < .10$). Results also indicate a high positive correlation between operators' trust in the automatic system and the time spent in automatic mode ($r(58) = .71$, $p < .0001$).

The study of Lee and Moray (1992) explores the development of a better understanding of

trust between humans and machines, more specifically, the investigation of trust influence on operator's allocation of function in human-computer systems. The conceptual framework is drawn from Barber (1983), Rempel, et al. (1985) and Zuboff (1988). Using 16 undergraduate students from introductory organizational behaviour and marketing courses, the study examines the effect of fault type magnitude on the level of trust and the performance of operators. Measures included subjective rating scales (10-point scales) modelled on those of Muir (1989); operators' level of trust and faith in the system, predictability of the system, and dependability of the system. Lee and Moray (1992) also study the effect of trust on the operator's control strategies. Findings suggested that both transient fault and chronic fault lead to a lower level of trust and a lower performance ($F(3,323) = 7.905$; $p < .0001$). The level of trust and performance returns to its initial level after several consecutive trials to correct the fault, except in the case of chronic fault where the trust did not return to its initial level. Fault magnitude affected the level of trust ($F(3,323) = 7.91$; $p < .0001$) but did not affect the controllers' performance ($F(3,323) = 2.37$; $p > .05$).

Three other studies dealt with the variable trust taking into account predictability (agreement), dependability (confidence), and performance attribution ratings.

Grounded in the works of Rempel, Holmes and Zanna's (1985) on interpersonal trust and source credibility, Lerch, Prietula and Kulik's (1997) series of experiments examine:

1. How three source pedigree (human expert, human novice or expert system) affected trust judgments.
2. What are the attributions made about a human expert and an expert system?
3. How the explanation mode (no explanation, prose-explanation, or rule-explanation) given by an expert system affected predictability and dependability.
4. How to increase thrust in expert systems by manipulating attributions (the description of the expert system as knowledge-linked or performance-linked in terms of comparison with a human expert).

Trust judgments measures include predictability as measured by a six-point agreement scale, dependability as measured by a four-point scale (confidence rating) and performance attribution rating: ability, task difficulty, effort, and luck (same scale used for confidence ratings) measured three times after each problem. Between 63 and 92 undergraduate students in an introductory organisational behaviour and marketing courses participated in one of the four experiments. In experiment 1, 92 students completed the following task: ten financial decision problems cast two-alternative choices (leasing or purchasing and public or private financing). Data was collected by subjects response to scales found on their individual computer. It was found that participants were less confident with advice from an expert system than advice from a human expert ($F(2, 89)=12.42$, $p < .001$). They rated efforts as contributing less to the expert system than to the performance of either human expert or novice. After a manipulation of the description of the expert system in experiment 4, 63 participants agreed more with advice presented by the Performance-linked expert system (described as performing better than a human expert) than that presented by the human expert ($F(2,64) = 6.23$, $p < .01$).

Interface. Selected studies in this group are concerned with people's feelings of trust. No reference was made to a specific theoretical framework. Kim and Moon four studies (1998) created a set of 40 bipolar emotive differential scales that represent the emotions felt in interacting with cyber-banking systems. They also isolated 14 factors important for the design of the visual interface, grouped in five categories. Using a factor analysis, the authors found that the 40 differential scales could be reduced to a seven-dimension emotion space. These dimensions are attractiveness-unattractiveness, symmetry-asymmetry, sophistication or lack thereof, trustworthiness-untrustworthiness, awkwardness, elegance, and simplicity. Of these seven dimensions, only symmetry (F = 124.55, p < .0001), trustworthiness (F = 189.93, p <.0001), awkwardness (F = 99.95, p < .0001), and elegance (F = 2097.99, p < .0001) were differentiated by the value of the 14 design factors[6] . The most important design factors related to trustworthiness-untrustworthiness were categories of main clipart and overall colour layout, which accounted for 72.6 % of the variance of trustworthiness-untrustworthiness. Finally, Kim and Moon (1998) manipulated the design of two interfaces with respect to main clipart and overall colour layout to find that these design factors have a significant effect on trustworthiness (F = 50.32, p = 0.001).

Of the seven studies examining the interface, four focus on people's responses to different interface types: text versus graphic displays, human-like versus machine-like, and talking-face versus text interface. Jones and McCormac's (1992) study examines users' opinion and the evaluation of computer-assisted learning in nurse education using 61 student nurses. No reference was made to a specific theoretical framework. Two questionnaires were used to measure university students' attitude[7] following their introduction to either graphic (MAC type) or textual (DOS) type interfaces. The questionnaires measured the extent to which subjects liked specific features and their thoughts on whether or not they would be easy to use. A mixed two-factor design was used in the analysis : MAC or DOS interface (all subjects used both) and order of exposure (MAC first, DOS first). Contrary to what was anticipated, the DOS type interface received a greater appreciation (e.g., ease of use and like) than the MAC type interface (p < .001)[8] . Also, there is a significant interaction between the interface type and order of exposure (p<.0001): the group using the MAC interface before using the DOS appreciated the MAC more. The authors explain these results by a difference in the users' pre-exposure, so they controlled this factor in a second study. The users continued to prefer the DOS type interface. However, the results are only significant for ease of use (p = .03). Sproull, Subramani, Kiesler, Walker and Waters (1991) examined the effects of interface type (talking-face - pleasant face, stern face- and text) and gender on social perception of the interface, social facilitation, and self-presentation using 130 university students. No reference to a specific theoretical framework was indicated.

Social perceptions were measured by a six-scale questionnaire (social evaluation, intellectual evaluation, sociability, activity, emotionality, and potency). Asking the subject "How relaxed did you feel?" and "How confident did you feel?" after using the interface

obtained arousal measures. Three scales measured self-presentation: the Marlowe-Crowne Social Desirability scale, the Philosophy of Human Nature Altruism scale and the Texas Social Behavior Inventory of Self-Worth. Planned contrasts indicated that there is no significant difference in the subjects' perception of attributes between the two faces. Therefore, subsequent analyses compare face and text interfaces. People respond to a talking face display differently than to a text display in terms of certain personality attributes: social evaluation ($F(2,118) = 5.85$, $p < .01$), sociability ($F(2,118) = 3.39$, $p < .05$), and activity ($F(2,118) = 3.93$, $p < .05$). There were no differences between the two types of interface with respect to intelligence, potency, and emotionality. Subjects reported themselves to be more aroused (less relaxed and assured) ($F(2, 119) = 3.64$, $p < .01$) by the faces than by the text interface. Regression analyses with self-worth as a covariate show that subjects present themselves in a more positive light to the talking-face displays ($F(2,119) = 5.61$, $p < .001$), and as more altruistic ($F(2,119) = 4.16$, $p < .001$).

In the same vein, De Laere, Lundgren and Howe (1998) measured the effects of evaluative feedback (positive or negative) conveyed through human-like versus machine-like computer interfaces on self- and reflected appraisals of performance and ability of individuals. Subjects were 158 volunteer undergraduates enrolled in an introductory psychology class. No reference to a specific theoretical framework. Reflected appraisal and self-appraisal were measured with eight seven-point rating scales based on the measure scales of Jussim et al. (1992) (and eight other scales composed of filler questions). Forty-two bipolar adjective rating scales (7-point) measured subjects' perceptions of the computer interface's characteristics on dimensions presumed relevant to the human-like versus machine-like manipulation based on Quintanar et al. (1982) and Wenger (1991). Results demonstrate that self- and reflected appraisals of performance were rated positively by subjects following positive feedback and negatively following negative feedback ($F(1, 150) = 169.79$,$p < .001$). Feedback direction also has an effect on self- and reflected appraisals of ability ($F(1,150) = 133.15$, $p < .001$). However, concerning the two communication styles, human-like or machine-like, no differences were found in the reflected appraisals process.

Song (1990) is interested in the emotional response of students confronted with different mathematical text styles. The sample was comprised of 20 undergraduate students enrolled in the first semester Business Calculus I. The dependent variable was emotional response. Its measure was based on Berlyne's study (1971). Four semantic scales bring the subjects to identify the degree of simplicity (simple-complex), clarity (clear-confusing), organization (organized-disorganized), and ease of use (easy-difficult). A 3 x 3 Latin square was used to counterbalance the possible effect of practice (proportional fonts, non proportional fonts, and keyboard emulation in which mathematics notation can be represented in alphabet x order of presentation of test materials, three possible combinations). Text style has a significant effect ($p < .01$) on degree of simplicity, clarity and ease of use. From an eyeball examination of the frequencies of response for these three variables, the proportional font style interface seems to be the best insofar as it

reduces adverse emotional effect.

A study by Tsai (1991) using 128 undergraduate and graduate students compared the effects of feedback, user-requested feedforward, and system-controlled feedforward on their performance in a computer-aided instruction (CAI) system about the BASIC language. Performance was measured using a 16-item pre-test and post-test. The higher order 2 x 2 x 2 factorial design shows that only feedback positively influences performance ($F(1,120)= 4.63$, $p < .05$). In addition, this effect is mediated by system-controlled feedforward ($F(1,120) = 4.17$, $p < .05$), that is, by system-initiated messages that guide student's learning.

Non-Quantitative Studies

The presentation of the goals leads to the identification of two groups of studies: those concerned with the nature of human-computer interactions and those focusing on the interface.

Nature of the human-computer interaction. Lynch (1990) analyzes the nature of human-computer interaction by comparing the reactions of students using Mac and IBM interfaces. Through systematic observation in the classroom, formal interviews, and informal questioning, Lynch (1990) compares the reactions of three groups of university students (no theoretical framework is mentioned). The first group (programming in a DOS environment) did not view the computer as personable and their interactions were those of a human with an appliance. The second group working at Apple II workstation referred to the computer as a more dynamic entity than did the first group. The third group (a computer literacy class working on both environment types, Macintosh and IBM-PS1) audibly responded to the computer, often to express frustration, but also to voice a surprise, such as the finding of a hidden feature. According to these results, the authors put forth the following hypothesis: "The Macintosh data indicated that the more inviting the perceptual and physical interface, the more likely the students are to see the computer as possessing a personality of a sort." (p.30).

The Cernuschi-Salkoff (1990) study examines the use of computers and school socialization. More specifically, they are interested in the students' perception of their interactions with computers and whether they received lessons on computers or not. No reference was made to a specific theoretical framework. Data collection methods for this exploratory research included questionnaire and interviews from a group of 21 and a group of 29, elementary school children between the ages of 9 and 11 years old. In this study, a majority of students said that the computer is intelligent and conscious, but not emotional. They would like "him" to have human qualities. After receiving some lessons on the machine itself, a majority of children (group 2) said that the computer is not intelligent. They also changed their view about the human qualities, such as feelings, that they would like the computer to have.

Grounded in the constructivism theory (computer as amplifier or reorganizer and computer's first effects and second order effects), Sesko (1993) investigates the meaning

and uses of computers in relation to gifted children. Based on early experiences of the study's four subjects, the contributing factors are the following: parents, games, and learning at home compared with learning at school (some children claim that computer experiences at elementary school are boring). Besides games, they first learn on their own by reading and talking with people (e.g., word processing, graphics, programming). For most of them, applications are amplifiers; that is to say that tasks are done faster and more efficiently when using those applications, but they are not changed. Some of them indicated second order effects (effects on higher-order thinking). All participants mentioned the following affective elements: fun, sociability (sense of being a group sharing a culture), creativity, freedom of expression, and accomplishment.

Orleans and Walters' (1996) study investigates human computer enmeshment (identity diffusion through mastery of the computer system). The data collection method was based in-group discussions. It describes the phenomenon of compulsive preoccupation with system configuration in terms of sense of workmanship, mastery enmeshment, and identity diffusion. The 12 subjects, described as computer devotees, express their sense of workmanship in setting their systems to maximize computing power. Collection of data occurred in the form of individual interviews and two discussion groups. They experienced a feeling of mastery insofar as they were able to optimize, customize, and personalize their systems. Subjects reported affective and cognitive changes. They progressively detached themselves form conventional social living and experienced a kind of conversion process to the computer world. A kind of intimate, quasi-social relationship evolved between the subjects and their systems. Concerning cognitive changes, subjects' identities became increasingly involved with the computer's intelligence.

Based on Austin's (1962) theory of meta-locutionary acts and Searle's (1969) speech-act theory, Novick's (1988) study focuses on the control of mixed- initiative discourse through meta-locutionary acts. The conversational interaction analysis of two dyads working at a cooperative problem-solving task led Novick (1988) to develop a model based on a theory of meta-locutionary acts which identifies three categories: reference/information acts, turn-taking acts, and acts repairing mutual model of the conversation among speakers. This model goes beyond those developed previously because it addresses control issues, uses situated action, and represents observed instead of idealized interaction. The results of the simulation based on this model indicate that meta-locutionary operators can plausibly provide the control processes, which lend coherence to mixed-initiative discourse.

Interface. Five studies examine the interface. Pritchard, Micceri, and Barrett (1989) study evaluates the interaction and learner control dimensions of software designed for educational purposes with no mention to a theoretical framework using the CITAR (Center for Interactive Technology, Applications, and Research) Computer Courseware Evaluation Model. They evaluated some 213 computer based teaching packages (IBM PC or compatible). The only results presented here are those focusing on the evaluation of the interaction and learner control dimensions. Evaluation of the interaction aspects shows

that 94.3% of the packages provided feedback to the learner, 47.9% of them used positive feedback for more than half of the course, 39 % provided on-line help, and 15.4 % proposed context-sensitive help. In 82.2% of the cases, the learner was able to respond by using single keystrokes, which can lead to absent-minded page turning. Evaluation of the learner control aspects indicates that only in a few cases (21.1%) were learners occasionally forced to wait a period of time before the lesson allowed continuation. In only 9.4% of the cases, this occurred during a significant portion of time. Learners had even greater control over the sequence of the lesson than over timing. Although most of the courses were sequenced in a strictly linear fashion, in only 7.5% of the courses was the learner not allowed to browse in some way through the lesson.

Robson and Crellin (1989) examine users' reactions throughout the process of software development, more precisely, the role of the user's perceived control in interface design. Robson and Crellin's study (1989) proposes and experiments a method permitting the evaluation of interfaces based on Rotter's Social learning theory and Kelly's personal construct psychology. The results show that Kelly's theory can provide a framework to investigate the user perceived control throughout the interaction with the computer. The methods also allow us to determine on which aspects the user's control acts: task, semantics, syntactics, or interactions. Robson and Crellin (1989) also reveal some difficulties in the application of construct elicitation system taken from Kelly's work. The results indicated that the subjects experienced difficulty in distinguishing the tasks that were to be performed[9] .

Based on the conversation analysis, using video-collected interactions as the data collection method, Norman and Thomas (1991) are interested in the main problems that arise during interactions with the computer. Concepts were drawn from ethnomethodology (Garfinkel, 1967): orderly and mutual intelligibility. Based on the results of six users from the Department of Computer Science, using several pieces of software, they pointed out an important problem of HCI: failures of the systems provide adequate responses from the user's point of view. They believe that machines should have the property of "interruptability". In addition, selections and actions should be seen as related instead of as discrete elements.

Hughes, Morris, and Plant's (1993) study examines the conversation users had with the computer, with or without access to telephones using 20 subjects (18 male and 4 female) from research personnel. They employed the methodology of conversational analysis (Heritage, 1988). Each subject completed a post-use questionnaire. Even though their study is not a quantitative one, these authors formulate four hypotheses. Following analysis of data that was collected using questionnaires it was found that three of the four hypotheses were true under certain circumstances, and one was confirmed. The following hypotheses, "Strict, Window-based WYSIWIS[10] is sufficient to present the illusions of single shared object" and "Voice contact supplants the need for explicit system floor control", were confirmed only under ideal conditions (i.e.,when users were already managing their turn-taking access to the documents). The task dominated conversations

only under special circumstances due to the subjects' difficulties during the first session. Finally, as the authors hypothesized, deictic reference to document material worked (this type of reference is shorter because it takes into account the fact that both users see the same document on their own screen, for example references to the "middle paragraph").

Using the participant observation data collection method, Woolgar (1991) also discusses the evaluation of computers systems via usability trials. He does this, however, from a much broader perspective than the other authors do, in this case, an ethnographical perspective (reflexive tie between the practical description of action and the assumptions which thus description exhibits). The sample was based on a medium company, which manufactured computers and allied products and an 18-month participant-observation in a company as a member of the project management team. Woolgar's main metaphor (1991) is "the machine as a text". In other words, " the nature and the capacity of the machine is, () interpretatively flexible" (p. 60). The examination of the processes of construction (writing) and use (reading) of a machine (a new range of microcomputers) leads the author to conclude that the machine, which mediates the relationship between readers and writers, "configures the user". The author indicates that the people involved in the design of a new microcomputer do not know the user. When information is collected from and about the users, this information is not communicated to all those concerned. Moreover, in order to collect data in as natural a setting as possible, they do not want to intrude. But in fact, they intervene a great deal. So, it could be said that in a certain way, the designed "machine text" creates its users.

Discussion And Conclusion

The present section focuses on the links between the quantitative and the non-quantitative studies. It also identifies future research directions most susceptible to contribute to the study of human-computer interaction in an educational setting.

Links Between the Two Bodies of Research Analysed

The quantitative and non-quantitative studies dealing with the nature of the human-computer interaction have common points. For example, in the quantitative studies, the methods used allowed researchers to explicitly examine the effect of the interlocutor with whom the user believed to be interacting (programmer or computer). They have also allowed researchers to see to what extent the expectations of the user are influenced by the user-friendliness of the interface. Non-quantitative studies covered such topics as the influence of elementary students' training, as well as the influence of the interface type on the students' perception of the computer thus these studies focus on similar subject matter. It is important to note that although half of the studies invite the subject to work at one time on a textual interface and at another time on a graphic interface, it is not so much the comparison between the interfaces that interests the researchers per se, but rather the effect that these interfaces have on the subjects' expectations or on their perception of the interaction.

Research dealt with two main variables: trust and control. Only quantitative studies dealt

with trust, as a dependant variable, referring to the conceptual frameworks of Barber and Rempel, Holmes and Zanna. Control is a variable that seems to be treated as much by quantitative research as by non-quantitative research. This variable is mainly studied through Rotter's Social learning theory. Quantitative studies examine the effect of this independent variable on compliance with computer-mediated commands or the moderating effect of compliance on the relationship between involvement and user attitude. In the case of non-quantitative studies, it is rather the user's perception of control, which is the focus of attention. Here again, the research complementarity is evident. On the one hand, the quantitative research considers the locus of control as an independent variable or as a moderating one, while on the other hand, the non-quantitative research measures it as a dependent variable. Although interesting, this choice creates theoretical problems, which will be discussed in the following section.

Up to the present time, as far as the study of interfaces is concerned, quantitative studies have compared graphic and textual interfaces, or various modes of screen presentation. The non-quantitative studies, primarily using research development methods, have explored the interface under development (production) in order to improve its design. Here, the complementarities of these studies concern the temporal aspect of the process of interface development.

Future Research Directions

It is essential to note that the study of student-computer interaction is still in its infancy. In fact, as discussed previously, only seven of the 34 studies examined have an educational purpose. Leads for future research in the study of student-computer interaction can be drawn from an examination of the quantitative and the non-quantitative studies reviewed here.

One of the first leads most certainly resides in the study of the nature of the student-computer interaction itself. In light of the results of all the studies analyzed, the problem of how the student qualifies the computer (partner or tool) arises. To what extent does it depend on the type of interface and on his success with computer use? According to Lynch's (1990) study, high school students are more inclined to personify the computer when the interface is user-friendlier. Hall and Cooper's (1991) study involving students showed that successful episodes while working on a computer were more often reported using impersonal references to the computer. Thus, a user-friendly interface should lead to success and consequently, lead to impersonal references. These results, contradictory in appearance, suggest the distinction between the success of the interaction and the success of the task accomplished through the interaction with the computer.

The quantitative studies, most often conducted in fields other than education, suggest several research directions related to the variables studied. The concept of control within the student-computer interaction must become the object of an in-depth examination. Several bodies of work, notably those of Richmond and McCroskey (1992), show the importance of considering the power and control of communication in an educational

setting. For example, Tsai's (1991) study invites researchers to examine the strategies that would lead students to control the display of information (feedforward or feedback). Furthermore, because of the ambiguity between "locus of control" and the "sense of control felt by the student", other studies must clearly define these concepts. According to Rotter's (1966) definition, the locus of control is seen as a personality trait. Though it may be modified throughout an individual's life, the locus of control cannot vary within a brief lapse of time according to punctual events. The authors who measure users' sense of control with a tool also used to measure the locus of control, actually take more of the user's personality trait into account than the user-friendliness of an interface according to the user's perceived control. It seems essential to first take into account the user's personality trait, and then to measure the perceived control during the use of a given interface; the perceived control can then be put in relation with the propensity of the individual to identify the control sources as internal or external to himself. Work on distributed cognition suggests a new framework to analyse this variable of control.

The studies treating variables such as compliance and trust raise questions which take on even more importance in educational settings. Insofar as Rosenthal's (1990) results show that subjects demonstrated significant levels of compliance with computer-mediated commands even in the presence of a competing source of authority, how will the teacher-student relationship be altered by learning activities which involve the computer on an even larger scale? These dimensions of student-computer interaction bring us back to the entire question of media education, in order to have the students to be able to evaluate the situations in which they can establish a relationship of trust and compliance. If this preoccupation has brought certain authors to suggest, for example, "to learn about television and not simply from it" (Jacquinot, 1985), at present, there is a rarity in exploration of the development of students' critical judgement in the face of all new media.

Furthermore, Robinson-Staveley and Cooper's (1990) study invites us to reflect, first of all on teachers' training in the use of computers, and secondly on the teaching strategies which involve the computer. The study showed that in the mere presence of another person, women having little experience in computer use performed less well, had a more negative attitude, and higher anxiety than men in the same category of experience. These results must be paired with the fact that most elementary school teachers are female and have little experience in using a computer. If these results are confirmed with a population of teachers, it would be beneficial to think of training strategies which may counter the negative effect of group work (individual work or in dyads where a relationship of trust can be established, for example). Other studies should equally examine if the mere presence of other people has similar effects on younger populations, such as elementary and high school students where group work is gaining ground.

Rapid technological developments also require that research continue on the types of interfaces used and on their impact on the nature of the student-computer relationship. The comparison of graphic and textual interfaces is no longer pertinent. However, comparison of design factors is still appropriate, as shown by the effect of the use of a

talking-face on arousal and on the way people present themselves. How could this type of interface be used for educational purposes?

Finally, some studies pose questions on a larger scale concerning the role of the school in the student-computer socialization. We cannot ignore the fact that the study involving gifted students shows that the school experiences in computer use were all judged to be boring. Research similar to Woolgar's (1991) must also be conducted in the school context, so as to better understand the mediator role of the computer between programmers and students, and also between teachers and students.

The studies on communication and, more specifically, on the teacher-student interaction, show the relevance of research concerning the student-computer interaction and its effect on learning (Webbels and Levy, 1993). This research on SCI should benefit from studies dealing with the more general HCI.

Hugues et al. (1993) as well as Stephanidis and Salvendy (1998) subscribe to this current research, which incorporates the area of human-computer interaction and computer-supported cooperative work. In education, the studies at the intersection of these two fields will have to increase as rapidly as the introduction of cooperative and collaborative learning and IT in schools. They should examine such variables as social engagement (Stephanidis and Salvendy, 1998) and motivation to collaborate with a co-learner which is a machine (Dillenbourg, 1996).

Acknowledgments

The research reported herein was supported by the FCAR (Quebec grant). We would like to thank Pauline Charest, Stéphane Thibodeau, Liza Henry, and Sandy Ward for their help

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Endnotes

1. The space constraints do not allow the presentation of these results in sufficient detail.

2. When information on theoretical frameworks is provided, the reader will find the reference in the studies analysed. In this article, we give only the references of texts analysed.

3. *F* statistic from ANOVA is not provided.

4. The *F* statistic is not provided.

5. The *F* statistic is not provided.

6. Due to space limitations, we do not report ANOVA results for the other three dimensions.

7. The variable "attitude" seems to be confused with the variable "opinion".

8. No *F* statistics reported.

9. It is noteworthy to say that in this article, it is difficult to adequately evaluate the methods used and the results obtained. Having no knowledge of the content of the software for which the interface is being tested - it seems that the software is made to evaluate software - the reader can hardly distinguish between the content of the software itself and the results of the study.

10. "What-you-see-is-what-I-see" is a phrase used to describe interface providing synchronicity of windows view.

ISSN: 1499-6685