Benefits of Virtual Characters in Computer Based Learning Environments: Claims and Evidence

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Abstract. Pedagogical theory of today gives high priority to social components of learning. Within the field of computer supported learning there are many attempts to acknowledge this. One approach involves the addition of virtual characters to electronic learning environments. Such *character enhanced* systems are the focus of the present article. Firstly, a systematic overview is given of pedagogical benefits that have been proposed in the literature regarding character enhancement of electronic learning environments, for example increased motivation, stimulation of particular learning activities, enhanced flow of communication and fulfillment of a need for deeper personal relationships in learning. Secondly, I examine the empirical results presented in the literature with respect to the proposed positive pedagogical effects. Based on these reviews, I finally discuss possible directions for continued research and design in the field from a pedagogical point of view. I propose a research agenda for the near future and conclude with some reflections on a longer-term perspective.

INTRODUCTION

Today, central pedagogical theories in various ways influenced by Vygotsky highlight the importance of social aspects for successful learning. It is emphasized that knowledge is socially constructed and that teaching as well as learning processes are inherently social, involving interaction, communication, negotiating and sharing (c.f. Vygotsky, 1987). Furthermore, it is pointed out that learning has emotional as well as cognitive facets. Specifically within the field of educational technology, many researchers and practitioners emphasize the role of social dimensions, and the importance of having technically supported learning situated in a social context. Articles and conferences in abundance address themes such as: 'social learning in multimedia,' 'socially interactive agents for learning,' 'enabling social presence in virtual environments,' 'personalized web companions,' 'artificial social actors,' 'learning companion agents,' 'character enhanced systems,' 'computer animation and social agents,' 'computer-supported social interaction,' 'the sociability of computer-supported collaborative learning environments,' and so on (e.g. Knoll & Jarvenpaa, 1995; Hietala & Niemirepo 1998; Höök et al., 2001; Kapoor et al., 2001; Kreijns & Kirschner, 2002; André & Rist, 2002; Dowling, 2002; Conference on Computer-supported social interaction, 2003; International conference on computer animation and social agents, 2003).

As can be noted in these citations, one important approach is that of adding various kinds of *virtual characters* to electronic learning systems. Some environments harbour so called animated pedagogical agents (e.g. Cassell et al., 1994; André et al., 1998; Paiva & Machado, 1998; Cassell & Thorisson, 1999; Shaw et al., 1999; Johnson et al., 2000; Lester et al., 2000; Kort et al., 2001), whose social character can be expressed by movements, gestures, facial expressions as well as voice, dialogue, etc. Other environments make use of virtual agents or characters that are not, or only to a limited extent, animated. One example of the latter is the Agneta & Frida system (Höök et al., 2000), where voices, looks, humour and dialogues are used to express the characters' personalities and inner lives. Similarly, the personalities of Hietala and Niemirepo's (1998) learning companion agents are comprised of a name, a picture and a personal voice and manner of speech (which is exploited as a central social feature).[1] Common to all systems is that a social context is created inside the computer (c.f. Hietala & Niemirepo, 1998), and that the technology provides an already populated social arena. Such learning environments may be called *intrinsically social*, in contrast to *extrinsically social* learning environments. In the latter, all social agency and all social activities are supplied by the human users of the system. The role of the technological system is to provide room and support for the activities. Here we find the rapidly growing area of computer supported cooperative learning (CSCL), with different kinds of support for discussion groups, on-line debates, chats, forums, arenas, etc. (Koschman, 1996; Dillenbourg, 2000).

Intrinsically and extrinsically social learning systems differ most markedly with respect to the case of a single individual user. An extrinsically social system, in fact, *requires* more than one user; otherwise, there will not be any social interaction. In an intrinsically social learning system, on the other hand, social interactivity can take place independently of any other human presence than that of one student.[2,3] There are also other differences between the two approaches in terms of constraints and potentials. Today, extrinsically social systems are commercially more widespread, whereas a majority of intrinsically social systems have the status of research prototypes. This is probably due to the fact that the architecture of an extrinsically social system is less complex, in the sense that there is little or no advanced artificial intelligence in the system. Potentially, however, intrinsically social systems may offer more possibilities to ensure the pedagogical quality of the social activities taking place in the learning environment. As an example, in letting children learn and practice language skills and storytelling by interacting and playing with a virtual peer - as in the case of the virtual learning companion Sam (Ryokai *et. al*., 2003) - it is possible to provide just the right amount of challenge in making the storytelling of the companion more advanced than the child's, but not too advanced. In other words, it is possible to ensure that a particular child or group of children gets appropriate, and high-quality, scaffolding.[4] In general, it is possible to modify the role, behaviour or expertise of a virtual

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[1] Not all virtual characters are embodied in the sense that there is a visualization of them. In this text, however, we focus on embodied virtual characters.

[2] Additionally, though, it may be possible for several human learners to collaborate and interact with respect to such a learning environment.

[3] There are also hybrid systems such as a pedagogical agent system designed to support multi-user collaborative exercises (Shaw *et. al*., 1999).

[4] And, for instance, make sure that the more advanced participants in a group - the 'help-teacher-students - themselves are being challenged and getting appropriate scaffolding.

fellow learner, for instance from that of an active leader to a weaker companion or even a passive observer, depending on a teachers' evaluation of whether the learner requires more or less guidance (c.f. Dowling, 2003; Hietala & Niemirepo, 1998).

In an extrinsically social learning system, on the other hand, the particular combination of roles, goals, status and expertise that happens to be there among students in a group (c.f. Dillenbourg, 2000), may be decisive for the pedagogical quality of the group interaction. Different combinations are more or less favourable from a pedagogical point of view, and in practical situations these factors are very hard to control. In general, one cannot order particular roles or expertise or pedagogical strategies from human beings, while virtual characters may be tailored for particular purposes, as regards teaching strategies (troublemaker, challenger, cooperator), roles (coach, instructor, companion), visualization, and so on. This leaves room to provide a student with more tailored learning situations.

In this review article I focus on intrinsically social learning systems and will use the term *character enhanced* learning systems (c.f. Höök et al., 2000). The two main questions addressed are the following: (i) what are the arguments in favour of character enhancement of computer based learning environments? and (ii) what are the empirical results with respect to these arguments? The structure of the paper is as follows: Firstly, I present the kinds of benefits of character enhancement that have been proposed in the literature: increased motivation, increased comfort with learning tasks, stimulation of particular learning activities, enhanced flow of information and communication, fulfilling the need for deeper personal relationship in learning and improved achievement in terms of memory, problem solving and understanding. Secondly, the empirical results presented in literature with respect to the argued positive effects are examined. In the literature surveys, I attempt to cover as many as possible of the major studies from the mid 1990's that are relevant to the questions examined. Thirdly, in a final part possible directions for continued research in the field of character enhanced computerized learning environments are discussed. I propose a near time research agenda and conclude with some reflections on a longer-term perspective.

CHARACTER ENHANCEMENT OF COMPUTER BASED LEARNING MATERIALS AND ENVIRONMENTS - PROPOSED GAINS

What is gained, from a pedagogical point of view, by enriching computer based learning materials and environments with virtual social characters? This section presents a survey of six kinds of positive effects that have been proposed: (i) increased motivation, (ii) increased sense of ease and comfort in a learning environment, (iii) stimulation of essential learning behaviours, (iv) increased smoothness of information and communication processes, (v) the fulfillment of a need for personal relationships in learning, and (vi) gains in terms of memory, understanding and problem solving. There are, of course, as several researchers point out (e.g. André & Rist, 2000; Dehn & van Mulken, 2000) potential relations between different kinds of gains. In a particular section I will address this issue.

Increased motivation

A frequently presented argument in favour of character enhancement[5] is that it will increase students' motivation to stay on in a learning environment and engage in the learning activities. Some different factors are proposed to produce the increased motivation: Learners may experience the environment and activities as more *entertaining* (van Mulken et al., 1998) or as more *likeable* (Sproull et al., 1997). As the environment becomes more social, the user's *engagement* will increase (Walker et al., 1994; Sproull et al., 1997; Moundridou & Virvou, 2002).

Lester and his colleagues (Elliott et al., 1999; Lester et al., 1997a, 1997b, 2001) emphasize that the addition of animated agents makes the computer more *lifelike* and that this increases its motivational impact.[6] They hold that the presence of lifelike characters in interactive learning environments, 'can have a strong positive effect on *students' perception of their learning experience*' (my italics, Elliott et al*., ibid.*, p. 4). The researchers name this *the persona effect*, and argue that 'the motivational benefits derived from the persona effect are compelling' (Elliott et al*., ibid*., p. 4).

Several researchers (e.g. Lee, 1999; Ball & Breese, 2000; Lester et al., 2000; Massaro et al., 2000; Kort et al*.,* 2001; Takeuchi et al*.,* 2001) point to the ability of social characters and agents to *show and elicit emotion* as a central factor behind the hypothesized increased motivation.[7]

Increased sense of ease and comfort with the learning tasks and the learning environment

Another argument for character enhancement of computer based learning environments is that the addition of a social character, or a set of social characters, can make the learner feel more comfortable and more at ease with the learning tasks and the learning environment. Van Mulken et al. (1998) propose that 'the presence of Persona may […] take away the fear of failure that some students experience with regard to particular educational material' (p. 63).

Stimulation of certain essential learning activities

It has also been proposed that certain crucial learning activities are stimulated or supported in character enhanced learning environments, for instance *explorative activities.* According to Höök et al. (2000) several studies show that the addition of characters encourages exploration of information materials, and a motive behind their own system (*ibid*.) is that the characters in the Agneta & Frida-system will encourage exploration. Similarly, the Affective Learning Companion by Picard and her colleagues (e.g. Kort et al., 2001; Kapoor et al., 2001) has as a main goal to

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[5] In the following, I will use the term 'character enhancement' as a short form for 'character enhancement of computer based environments'.

[6] An experience of the computer as more lifelike may, in turn, produce an experience of the learning environment and activities as more entertaining, likeable or engaging.

[7] Emotional aspects may, in turn, produce an experience of the system environment and activities as more entertaining, engaging and likeable.

'keep a learner's exploration going'. Johnson et al. (2003) underline the same potential of animated agents, namely to promote students' curiosity.

Another element often considered essential to learning is *reflection*. Some researchers (e.g. Goodman et al., 1998; Tholander et al., 1999a) focus on the potential of a social character to support the learner in reflective activities by encouraging him or her to use language for articulation of his or her ongoing activities. Social characters are also held to enable and encourage *dialogue and cooperative learning*, in particular in the case when the social agent is a learning companion (e.g. Chan, 1996; Goodman et al., 1998; Kapoor et al., 2001).

Attention - while hard to define and operationalize - is another crucial learning element. Increased attention is one proposed gain of character enhancement, both in the sense that (i) character enhancement can make a learner pay attention at all and be engaged in learning activities, and in the sense that (ii) characters can guide learners' attention through a material in a thoughtful way. André et al. (1998) for instance, focus on the advantage of characters in that they, by attracting a user's focus of attention, can guide her or him through a presentation. Rickel and Johnson (2000) likewise lift forward the possibility that an animated agent can draw a student's attention to specific aspects of a virtual world.

Enhanced flow of information and communication

Some researchers hold that a central gain when adding social characters to a pedagogical interactive system is an improved flow of information and communication (e.g. Cassell & Thorisson, 1999; Shaw et al., 1999). An animated social character that gives feedback in the form of gazes, smiles or nods, or which points and demonstrates with its body, opens up for rich and smooth interaction. Human beings are accustomed to interact with other social actors, that is, other humans, and the more one can resemble such information and communication processes in a learning environment, the better the attained flow of information will be. An underlying idea is that the naturalness of interaction between human beings, and the bandwidth of multi-modal interaction that we are capable of, is to be emulated or recreated in artificial actors. According to Shaw et al. (*ibid.*) the main motive of working with pedagogical agents is to 'make it possible to more accurately model the kinds of dialogs and interactions that occur during apprenticeship learning and one-to-one tutoring [where] factors such as gaze, eye contact, body language and emotional expression can be modelled and exploited for instructional purposes' (p. 283). Massaro et al. (2000) reason along similar lines: As animated characters can provide many sources of valuable and effective information in a natural manner, this will facilitate and enrich the interaction between human and machine in a learning context. And Oviatt and Adams (2000) whose research is driven by the long-term overall goal of developing robust interfaces for children 'that make effective use of animated characters for purposes like education' (p. 321), hold that with 'social interfaces' it will be possible to obtain more transparent, high bandwidth and relatively natural multi-modal communication.

Fulfilling the need for deeper personal relationship in learning

A social context can make possible and support interactive and cooperative activities of different kinds, but it can do more: it can also make deeper personal relations possible. Bickmore (2002) advocates what he calls *relational agents*, which are computational artefacts designed to build

and maintain long-term, social-emotional relationships with their users. He holds that 'humans have a need to engage in substantive and deep social interaction, not only in what we call social contexts but also in explicitly task-oriented contexts'. In education, he maintains, 'the establishing of personal relationships is absolutely crucial' (p. 1). The proposal, thus, is that personal relationships in a deeper sense, not a more shallow social interaction, is the prime value that can be gained from character enhancement of computer based learning environments. Such deeper personal relationships are essential in order to achieve outcomes of significant benefits for users of computers, in particular in learning contexts. (See also Bickmore & Picard, 2003.) Also Moreno et al. (2001) propose that a main value in a pedagogical animated agent lies in it acting as a '*personal* tutor' (p. 183, my italics).

Positive effects on learning achievements in terms of memory, problem solving and understanding

Finally, positive effects in terms of improved memory, problem solving, knowledge transfer or understanding are proposed as potential gains of character enhancement. Lester et al. (1997a) propose that virtual animated characters, in addition to their significant motivational benefits, increase students' problem-solving effectiveness. Similarly, Johnson et al. (2003) describe animated pedagogical agents as a promising means for making computer-aided learning more efficient in that agents may scaffold learning activities such as problem solving. Moreno et al. (2001) suggest that a social agency environment built around an animated pedagogical agent, will encourage learners to make a stronger effort to understand a material and thus results in increased understanding and an improved capacity for knowledge transfer.

Potential relations between effects

There are potential relations between several of the discussed effects or gains, and some authors discuss such relations. Specifically, the possible relations between motivational gains and activity gains and, in turn, between activity gains and achievement gains have been pointed out. 'A greater entertainment value of a tutoring system might lead the student to interact with a system more frequently, thus eventually leading to superior learning achievements' (Dehn & van Mulken, 2000, p. 17). Moundridou et al. (2002) state that an increase in students' motivation may show positive results in learning outcomes in the long run, and André & Rist (2000), as well, suggest that people possibly learn more about a subject matter because they are willing to spend more time with a system.

Indeed there is intuitive appeal in the argument that if a learning environment or material is found engaging - that is, experienced as involving, interesting or as having impact - it is likely that users will become more active, stay on longer and produce more, which may, in turn, have effects on learning achievements. The first part in the argument, namely that there is a relation between motivation and activation, gets support from the theory of intrinsic motivation (Keller, 1983; Malone, 1981). However, in empirical studies it is necessary to sort out which effects are measured and which related effects are only hypothesized.

EMPIRICAL RESULTS WITH RESPECT TO THE PROPOSED POSITIVE EFFECTS

Increased motivation

The concept of motivation is complex, and empirical studies have to exploit some or other operationalization of it. One possible measurement is the length of time that learners spend with a character enhanced versus a neutral system, where longer time spent is interpreted as higher motivation. However, a prerequisite is that there is no specific task that the learners are asked to accomplish. If there is such a specific task, a longer time spent could also be interpreted as it being more difficult to understand or work within the environment.

Höök et al. (2000) compared the average time spent by a group of eighteen participants who used a character enhanced system called Agneta & Frida (the 'with A&F' group) and a group of twenty participants who used the system without characters (the 'without A&F group'). The participants were told to look around and check out a collection of web links about movies, and the study was set up with the intention to allow subjects to feel free to do what they wanted and stay as long as they wanted. The subjects in the 'with A&F group' spent on the average 27.4 minutes with the system versus 20.7 minutes on the average for subjects in the 'without A&F group'. The difference is not significant as the standard deviation is large, but the tendency is towards the 'with A&F group' spending longer time.

A study that deserves particular attention is Bickmore's (2003) of the use of an exercise adoption program involving a virtual trainer agent, named Laura. The Laura project, exceptionally, deals with long-term interaction within a learning context; the virtual trainer agent being designed to interact repeatedly with users during several weeks. Participants in the study were during four weeks able to log in as often as they liked and spend as much time as they liked viewing educational pages related to the training program. One of Bickmore's hypotheses was that the group that used the exercise adoption program *with* the virtual trainer would log in more frequently and would view a larger number of educational pages than the group that used a version of the program *without* the virtual trainer. The hypothesis was partly supported. There was a significant difference, in the hypothesized direction, in the number of pages viewed, but no difference in the numbers of log-ins.

A number of studies use questionnaires or interviews, where participants are questioned about their experiences, to measure the motivational effects of character enhancement. Many of these studies give support to the hypothesis that character enhanced systems are experienced as more entertaining, likeable or engaging. Some results regard explicitly pedagogical applications (Lester et al., 1997b; Lester et al., 2001; Moreno et al., 2001; Moundridou & Virvou, 2002; Johnson et al., 2003). Other results regard other kinds of information and knowledge applications (Takeuchi & Naito, 1995; Koda & Maes, 1996; André et al., 1998; van Mulken et al., 1998; Höök et al., 2000)[8].

In sum, a number of studies support the proposal that the use of social characters in knowledge-based systems of various kinds may have a considerable motivational impact. Many

[8] Even though the latter do not focus on educational dialogue and interaction, they involve many elements such as the presentation of materials, and guidance through materials, that are important aspects of educational applications.

users experience these systems as more lively and engaging (c.f. André & Rist, 2000). However, three qualifications should be made.

First, with the exception of Bickmore's (2003) virtual trainer study, there are to date no studies on long-term effects of character enhanced learning systems (c.f. Dehn & van Mulken, 2000). Thus, little is known about motivational effects in the long run: what happens when a learner over a long period of time is given possibilities to use such systems and to choose to return or not return to them?

Second, the positive results concerning motivational effects derive from (i) comparisons between *groups* of subjects, with one but not the other group using a character enhanced version of a system, and from (ii) studies where *a group* of subjects are asked to compare a character enhanced version of a system with a non character enhanced version. When taking a more fine-grained perspective that looks at *individual* results, one finds a subgroup of subjects who *do not* appreciate the character enhanced systems. For instance, Höök et al. (2000), report that a third of the eighteen participants tended to express negative views about the character enhancement, finding them irritating or disturbing, and not fun. These participants also, not surprisingly, expressed comparatively little willingness to use the system again. In related research, Tholander et al. (1999 b) report that out of the two groups who got to use an assistant in a modelling task, one group believed that the assistant provided useful information while the other group thought it was in their way. In a study by Gulz (2002) participants were asked to choose between two interfaces - a socially elaborated interface and a spatially elaborated interface - to an information system about books, and asked to give reasons for their choices. From the motivations given, it was clear that social enrichment was appreciated by some (e.g. 'I chose it because it is more personal, about people, individuals', 'I find a social context more stimulating to explore' and 'It's more natural and easy for me to relate to the people than to the park') but disliked by others (e.g. 'I don't want to know things about those people' and 'The people only complicate things'). It seems, in sum, that character enhancement can evoke strong reactions - positive as well as negative.

Third, not only do we find divergence in motivational effects in individuals, there is also evidence that motivational effects vary with the kind of content or subject dealt with in the learning environment in question. In a study by van Mulken et al. (1998) the character-enhanced system - the PPP Persona system - was experienced as more entertaining than the system without the PPP Persona, when the function of the system was to explain a technical device. But when the function of the system was that of introducing fictitious employees of a research institute, there was no difference in entertainment ratings between the character enhanced and the system that was not character enhanced. Dehn & van Mulken (2000) speculate that the reason for this discrepancy can be that, if a system is visually attractive from the start, as they argue was the case with the employee introducing application, character enhancement might not make any difference as concerns motivational effects.

Increased sense of ease and comfort with the learning tasks and learning environment

An important result in Mulken et al.'s (1998) study was, that the mere presence of a character in a technical presentation appeared to influence the subjects' perception of the difficulty of both the presentation and the recall test. Subjects who had used the character enhanced version judged the

technical presentation as significantly less hard to understand than subjects who had used the system without character enhancement. Subjects who had used the character enhanced version also rated the recall test as significantly less difficult than subjects who had used the unenhanced version. However, there were no actual performance differences between the groups, neither in comprehension nor in recall.

Moundridou and Virvou (2002), similarly, found that students who worked with an agent version of an intelligent tutoring system, found the maths problems that they solved significantly less difficult than students working with the intelligent tutoring system without an agent, despite the fact that the performance of both groups of students was similar.

This effect - an increased sense of ease and comfort with a learning task and environment - is of course interesting from a pedagogical point of view. However, as with the motivational effect, discussed above, we have no reason to believe it to be a panacea. Rather, empirical evidence indicates that there is significant individual variation also as regards the effect of an increased sense of ease and comfort with a learning task and environment. In the Höök et al.'s study (*ibid.*) some of the subjects did not feel at ease but were stressed, irritated and disturbed by the characters. Reeves and Rickenberg (2000) used a series of Likert Scales (for instance 'I felt relaxed', 'I felt strained') to assess anxiety vs. relaxation in subjects who used a system with a monitoring and interacting animated character, and found large individual variation among subjects. The results can be summed up by the following passage from André & Rist (2000): '[…] there is no "standard user". Rather, the members of a user population can differ widely with regard to personality and individual preferences for a certain style of acquiring new information. In fact, some people feel less comfortable when being approached directly by an agent' (p. 1). Additionally, it is unclear whether effects of increased comfort in a learning environment depend upon the character of the environment and tasks (van Mulken et al., 1998).

Stimulation of particular essential learning activities

Is there evidence that explorative activities, attention, cooperative activities or reflection is positively affected by character enhancement of computer based learning environments?

Höök et al. (2000) compared the time spent and the number of sites explored by subjects who used the character enhanced Agneta & Frida system and by subjects who used the system without character enhancement. They conclude that their 'study showed that the Agneta & Frida system *encouraged subjects to explore more of the space* and to stay longer in the space' (my italics; p 208).[9]

Regarding studies on the effects of character enhancement on *attention* and concentration, there is no concensus on how to measure attention and on how to interpret different measurements (c.f. Dehn & van Mulken, 2000; Moundridou & Virvou, 2002). Takeuchi and Naito (1995) interpret the longer response time in users in the character condition when playing a card game, as compared to users in the non-character condition, as an indication of a lower degree of attentiveness. The authors conclude that the character distracts users from the game. Sproull et al. (1997), on the contrary, interpret the longer time taken by subjects in the character

[9] Höök et al. (*ibid*) also refer to the studies by van Mulken et al. (1998) and Lester et al. (1997b) as studies that support the idea 'that characters encourage exploration of a given information space in relation to learning and creativity' (p. 196).

enhanced condition when answering psychological test items as reflecting a higher degree of attentiveness. Their conclusion is that people are more attentive to a task presented by a character than to one presented by a textual display. An issue that is closely related to the conflicting interpretations of time spent with respect to attention and learning, and that is discussed by several researchers, is the following: When does attentiveness to a character help a student focus on the learning tasks and activities as such, and when does it function as a distractor? (e.g. van Mulken et al., 1998; Rickenberg & Reeves, 2000; Moreno et al., 2001; Craig et al., 2002.)

In a study by Tholander et al. (1999b) a distracting effect was indicated. Ten pairs of students were asked to perform a modelling task within the area of object-oriented analysis. Two pairs were supplied with a virtual pedagogical assistant, two pairs given a pattern library, two pairs supplied with an expert track, two pairs supplied with all three tools and two pairs given no tool. An observation of the groups that used all the tools was that the virtual assistant had a tendency to take too much attention away from the other two tools.

Moundrido and Virvou (2002) applied the criterion of 'longer time spent, but not *too* long' - numerically spelt out - to stand for higher attentiveness in a study, where students worked with mathematical problems. No difference in attentiveness was found between students using character enhanced and non character-enhanced systems. Craig et al. (2002), who measured attentiveness during a short time span, found no difference in so called split attention effects between a character condition and a characterless condition.

In the Tholander et al. (*ibid.*) study described above, one hypothesis was that the virtual assistant would help subjects spend more time and effort to critically *reflect* upon their model and evaluate their solutions. However, the study gave no clear evidence that this was the case. Sometimes when the assistant commented on some important aspects of the domain that needed to be covered in the model, the students would indeed evaluate and reflect on their model. But sometimes comments were a source of confusion.

As concerns *cooperative behaviour*, it is, on the one hand, obvious that a character enhanced system offers extended possibilities for cooperation compared to a corresponding system without characters. The issue is rather whether - and how - it is possible to obtain cooperative behaviour of a sufficient naturalness and quality in a character enhanced computerized learning system. In a study by Keissler and Sproull (1997), three different character enhanced conditions as well as the condition of real human-human interaction were compared with respect to cooperation. The human partner, a confederate, communicated through desktop video. One character was based on an image of the confederate's face, another character was based on an image of a pet dog, and the third character was based on a cartoon drawing of a dog. The result was that participants cooperated highly and equally often with the person-like character and the confederate (the real person), but significantly less with the other two characters.

In sum, the evidence as regards positive influence of character enhanced environments on certain important learning behaviours is rather mixed. Furthermore, most evidence consists of single studies rather than a series of studies, systematically approaching an issue. It is therefore not possible to generalize the results to other kinds of systems, other learning situations and other instantiations of character enhancement. In particular, long-term learning is rarely addressed in the studies.

Enhanced flow of information

The proposed gain of enhanced and more natural communication takes the rich and smooth communicative processes in human-human learning as its starting point. Character enhanced computerized learning environments, it is suggested, offer the promise of modelling or emulating (aspects of) this. The empirical studies that relate to the proposal are, in general, design and development oriented.

Evaluations with respect to the claim are carried out in different forms. Sometimes they involve comparisons between a particular learning environment with and without animated characters, but more frequently a character enhanced environment is evaluated as such (e.g. Massaro et al., 2000), sometimes being compared to the human-human interaction case (e.g. Oviatt & Adams, 2000). In other studies several different character enhanced environments are compared (e.g. Cassell & Thorisson, 1999).

Massaro et al. (2000) describe a study where the animated character Baldi - a computer-animated talking head - functions as a classroom tutor for language training for children with hearing loss. The study showed that Baldi helped the children to correctly interpret auditory speech, in other words, helped to increase the smoothness of dialogue interaction.

Oviatt and Adams (2000) compared childrens' conversing and interacting with a set of animated characters to childrens' conversing with adult human beings. Results were that the childrens' speech when directed at the animated characters was significantly more repetitive and clearer or more hyper-articulated, than was their speech when directed at an adult human. This may, according to the authors, indicate that the children view their computer partner as a kind of 'at-risk' listener. In other words, the interaction, in terms of conversation with the characters in this environment, did not attain the smooth and natural conversational pattern that is achieved in interaction with another (adult) human being.

Cassell and Thorisson (1999) compared three different animated agents that communicated with learners about the solar system. One agent just provided answers to questions. The second agent in addition to this also produced emotional responses, for instance smiling when addressed by the user. The third agent, defined as the most communicative agent or the discourse-supporting agent, was similar to the first but additionally turned head and eyes towards the user when expecting a request, etc. The hypothesis was that the flow of interaction would be smoother with the third agent than with the two others, in the sense that the user would make a smaller number of repetitions and hesitations, and that there would be less communicational overlaps. The result did indeed show that the relative number of repetitions was significantly lower in the interaction with the third agent. Also when subjects were asked to rate the smoothness of the interaction, the condition with the third agent was rated significantly higher than the other two conditions. However, contrary to the expectations, the number of hesitations and overlaps was significantly higher in the interaction with the third agent. The authors explain the unexpected result by arguing that a larger number of overlaps and hesitations might in fact be an indicator of a more natural interaction.

In sum, a number of studies have been conducted, but they differ, among other things, in the kind of evaluation or comparison that is used. Compared to the case of 'no character' at all, it seems fair to say that character enhancement brings about an improvement in communication. Compared to the human-human-case, on the other hand, there is a long way still to go.

Fulfilling the need for deeper personal relationships in learning

The claim that character enhancement can be used to fulfil a need for deeper personal relationships in learning is, just as the claim that it can increase naturalness of communication, closely related to a modelling endeavour. The starting point is the existence of personal relationships in human-human learning, and attempts are made to recreate or emulate (aspects of) such relationships.

Among studies related to the proposal are the following. Oviatt et al. (2000) use the terminology of 'new friends' when reporting on how absorbed the six-to-ten-year old children in their study sometimes were with the animated characters (pp. 339-340). The researchers also report signs of social relations: 'children spoke directly to the animals using personal pronouns, and approximately one-third of all the content exchanged involved social questions initiated by the child about the animated character's name, birthday, personal characteristics, friends, and family life' (p. 339). Subjects in Höök et al.'s (2000) study were asked whether the Agneta and Frida characters 'feel like friends' on a scale from 1 to 7, where 1 stands for 'not at all' and 7 stands for 'very much'. Nine out of eighteen participants gave ratings between five and seven.

Tim Bickmore, who is one of the leading proponents of the idea that computer based environments can and should make room for deeper social relations, worked during several years with the development of the animated character REA, a real estate agent. Among the mechanisms in the building of personal relationships that were studied in the REA projects was that of 'small talk'. An interesting result (Bickmore, 2002) with respect to this was the indication of significant individual differences: many participants felt strongly about their *like*, and many felt strongly about their *dislike* of small talk with an animated character.

In the later developed agent, the virtual trainer agent Laura (Bickmore, 2003), more sophisticated relational and social attributes are being modelled[10]. Specifically there is development of so called relational cues, something that is assumed be important in the building of human relationships. Over time, the following cues develop in Laura: more frequent eyebrow raises, hand gestures and communicative head-nods; less frequent gaze-aways; more frequently coming close. Results of a between-subjects experimental design (Bickmore & Picard, 2003; Bickmore, 2003*)* indicated that when the virtual coach used these relationship building strategies, users reported more liking, trusting and respect for the agent, and reported an increased desire to continue working with it, compared with users in the so called non-relational condition. Some participants in the study explicitly stated, for instance, that “My relationship with Laura is very important to me" (Bickmore, 2003, p. 189) or that “Laura and I care about each other" (*ibid*., p. 189). But there were also participants who expressed quite a different attitude, for instance declaring that “I felt like I was talking to a robot, to a machine" (*ibid*., p. 186) or that “[ ] I liked all of the software except for the animated conversation thing" (*ibid*., p. 185).

In sum, it has been demonstrated that people can develop some different kinds of personal relationships to virtual characters[11] in educational contexts. It has also been shown, though, that reactions and attitudes towards such a personal relation aspect differ considerably between individuals (Bickmore, 2003). We conclude this section with an attempt to relate these two findings to Reeves' and Nass' (1996) influential *media equation*, i.e. that a computer, and even

[10] Or rather, in one of the implementations of the agent.
[11] As well as to other kinds of computer artefacts, such as Tamaguchis.

more so an anthropomorphic projection such as a computer character, is treated as a social actor by human users (Nass et al., 1994). In a series of studies, Nass, Reeves and co-workers have shown that human beings transfer social expectations and strategies used in the encounter of human beings to the case when there is a computer instead of a person in front of us.

The first finding, that people, who interact with a virtual character endowed with various social attributes, describe their relation to the character in terms of a personal relationship, is of course compatible with Reeves and Nass (1996). The finding however goes beyond what Reeves Nass actually speak about. Their focus is on how people behave in front of a computer and what this tells us about peoples' strategies and expectations. They are not concerned with the extent to which people explicitly declare that they experience a friendship, a personal relationship or the like.

It is more of an open question whether the second finding, concerning the considerable differences in how individuals react to and express their attitudes towards virtual characters, is compatible or not with the Nass and Reeves' framework. What we have is that, given a particular virtual character, endowed with more or less sophisticated social cues, some individuals willingly respond by being social in return and seemingly appreciating the situation, whereas others react with repudiation and, as soon as they can, shut the computer or the animated character off. The question is whether this pattern of differences has some correspondence in the non-virtual world. Is there a media equation or not in this respect?

Positive effects on learning achievement in terms of memory, problem solving, and understanding

Lester et al. (1997b) hold that their study 'demonstrates that animated pedagogical agents can yield important educational benefits in the form of improved problem solving' (p. 23). This conclusion is, however, problematic, as the actual study involves only five conditions where different kinds of agents are compared with one another and no condition *without* an animated pedagogical agent. Graesser et al. (2001) compare the learning results of students who used an intelligent tutoring system with the pedagogical agent AutoTutor to the learning results of students in a control condition who read yoked chapters in the book. Given the conditions that are compared, the outcome that 'that Autotutor improves learning by .5 standard deviation units' (p. 4) does thus not have any bearing upon the issue of whether character enhancement has positive effects on learning.

A number of studies provide negative evidence for the hypothesis that character enhancement has beneficial effects on memory, problem solving and understanding. Van Mulken et al. (1998) showed no positive effect of an animated character on comprehension and recall in learning new information, for neither technical information nor non-technical information. There was also no positive effect on problem solving. Höök et al. (2000) found no difference between subjects using the character enhanced system and subjects using the system without characters, in terms of how much they remembered of web page content. Moundridou and Virvou (2002) present 'the not encouraging finding […] that the presence of an interface agent did not manage to improve the short-term learning outcomes significantly' (p. 260). Moreno et al. (2001) compared subjects who learned about botanical physiology by interacting with an animated pedagogical agent who spoke to them, with subjects who received identical graphics and

explanations as on-screen text without a pedagogical agent. No differences were found on retention tests.

A positive result, though, comes from the same set of studies by Moreno et al. (2001). On a transfer test where students were asked to apply what they had learned to solve new, relatively difficult, problems, the group who had used the character enhanced system outperformed the group that had used the system without the animated pedagogical agent. The authors speculate that the animated pedagogical agents may '*personalize the learning task* and help students feel a *positive personal relationship with the agent*' which '*promotes interest in the learning task* […] More motivated students *try harder to make sense* of the presented material than do less motivated students. They are also more likely to *form coherent mental models* that enable them to apply what they learned to challenging new problem-solving situations' (*ibid*., p. 193, my italics). Even though this chain of explanation may be intuitively appealing, it remains basically speculative.

Craig et al. (2002) present a result that in some respects parallels that of Moreno *et. al.'s*. In the study the three conditions, no agent, an agent without gesture and an agent with gestures were compared. No differences were found on a retention task, but on transfer questions there was a significant positive effect from the agent with gestures condition over the two other conditions. Craig et al. (*ibid*.) point out, however, that their study involves very brief information delivery and that it is 'not clear whether similar findings would be obtained in longer term learning sessions' (*ibid.*, p. 433). Ryokai et al. (2003) in discussing a study of young children, who play and tell stories together with the virtual peer Sam, as compared to children who play and tell stories without Sam, make a similar reservation. The comparisons indeed suggest that children who played with the virtual peer told stories that more closely resembled the virtual peer's linguistically advanced stories. 'However the duration of the study is not sufficient to conclude that the children actually *learned* these behaviours from *Sam*' (p. 202).

CONCLUSION AND DISCUSSION

Summing up, none of the suggested pedagogical benefits of character enhancement discussed in the article is supported by unambiguous evidence. Instead, evidence is rather scattered and sometimes contradictory. Studies diverge in their methods of evaluation: character vs. non-character; character vs. human being; character version 1 vs. character version 2, etc. Many studies are pilot studies, and thus, their results are difficult to generalize. A particularly significant shortcoming of current evidence is that most studies leave us without knowledge of what happens when learners are involved in repeated interactions with social characters over a longer period of time. As a result we know little about potential effects of character enhancement of computerized learning environments in ecologically valid contexts.

The fact that we are left with such uncertainty, in spite of about a decade of intense research and development within the field, can be interpreted as reflecting the field's complexity. Also, it can be argued that we are still at a very early stage in the development of character enhanced systems, and consequently it is too early to go into evaluations of potential benefits of these kinds of learning environments. We have to await systems that are built for long-term real use and leave short-time lab studies behind. Evaluations today are bound to give uncertain results.

Even though these lines of argument are sound, it is important to acknowledge that there are several systems out there in the market place. Character enhancement of pedagogical systems is far from a pure R&D-phenomenon, which, in turn, entails some responsibility for the research domain. The following questions may, for instance, be posed:

- Is there anything in the hitherto collected knowledge that can be immediately applied in order to improve the character enhanced learning systems that are produced today?
- Are there any of the proposed pedagogical gains that seem sufficiently promising to merit focused, systematic research also in a shorter time perspective?

These issues will be briefly addressed below, followed by some reflections on a longer time perspective.

Research agenda in a shorter time perspective

Two of the potential pedagogical benefits from character enhancement that have been discussed above differ, in our opinion, somewhat from the rest: (i) increased motivation and (ii) increased sense of ease and comfort with tasks and learning environments. These proposed benefits are not so strongly associated with an idea of re-creating or emulating the human case, and are therefore less bound to having to await technological progress that can make emulation of the human case possible. They are of interest also given the aim of developing as successful character enhanced systems as possible today, and merit to be the focus of systematic studies in the near future. Among the critical parameters that ought to be involved in such short term studies, we propose the following: different pedagogical roles and strategies of virtual characters; aspects of visualization; user diversity; and repeated interactions over longer periods of time. Below I discuss why I hold that these parameters should be put on the short term research agenda.

Different pedagogical roles and strategies of virtual characters

Virtual characters can take on several kinds of roles: more authoritative ones as instructors, guides or coaches and less authoritative ones as different kinds of companions (c.f. Chou et. al., 2003). An instructor or coach may, furthermore, use active and intervening strategies or be more passive, only responding to requests for assistance by the learner. A companion may, for instance, be competitive, collaborative or act as a troublemaker (c.f. Chou et. al., 2003). Systematic, comparative research on the potentials of roles and strategies, as to how and when they affect motivation and comfort with tasks in users, would be useful. I propose large-scale studies that systematically compare effects in terms of motivational impact (and also learning achievements, when possible) between different roles/strategies in virtual characters. For instance, when and for which learners does the strategy of opportunistic teaching that is implemented in some pedagogical agents (Shaw et al., 1999; Lester et al., 2001) have positive effects on motivation and sense of comfort and when is it found to be irritating, pushy or tactless? (C.f. Tholander et. al., 1999 b; Johnson, 2003; Gulz et. al., 2004).

Specifically we need to systematically address possible variations due to age, gender, and culture, in order to provide guidelines as to what pedagogical roles and strategies in virtual characters are worth having and to elaborate in different learning contexts. Such guidelines would be useful both for continued research and for development of environments to be used commercially.

Aspects of visualization; realism vs. iconization; choice of face, body and clothing; visual style; animation vs. still graphics

To date very little research has dealt with the visual aspects of virtual characters. With respect to the potential of character enhanced systems to motivate and to increase the impact of learning activities on users, this research gap deserves to be filled out. In the case of people interacting with real people, there is ample evidence that interpretations of appearance and observable physical cues profoundly affect both beliefs and behaviour. The visual appearance of a human being produces an impression of personality, which initiates a set of attitudes and expectations in others (e.g., McArthur, 1982; Kalick, 1988; Branham, 2001). One of the few studies that address the visual appearance of virtual characters by Lee & Nass (1998), demonstrates that this factor seems critical for how people access virtual characters as well. The authors argue, that the visual appearance influences peoples' preferences in terms of looking at and even interacting with a virtual character. Within the related domain of computer games, Gard (2002), in discussing the design of computer game characters, claims that 'a person's first impression of a character will almost certainly come not from what they do, think, or say, but what they look like. If the character makes a good first visual impression, players will likely stay focused on it, allowing you to further entice them with the character's personality' (p. 4-5).

Not only do human beings form impressions of someone's personality based on physical appearance, these impressions also persist and deepen over time (Mathes, 1975). Relatedly, Gard (2000) claims that even though our opinions on a person's personality may be reformed after a while, it will 'for a long time […] still [be] filtered through our preconceptions based on our first impressions. So to create a really good character, you have to control all of the visual clues that people use to judge each other and establish a clear, unified message to make players interested in — and ultimately like — your character.' (p. 3).

An implication of all that has been said above is that if the goal of virtual characters is to motivate, engage and adequately impact learners - and/or to increase a learner's sense of ease and comfort with tasks - visual appearance ought to be carefully articulated in research and development of such characters. For more detailed arguments, see Gulz & Haake (submitted).

Regarding realism versus iconization (e.g. cartoonish) in visual rendering - which is a variable that can be manipulated only in the virtual, not the real world - we find diverging claims with respect to how this choice affects a character's impact and ability to involve (Gulz & Haake, submitted) but few corresponding empirical studies. However, empirical studies would be useful in order to sort out the issue and be able to provide guidelines both for continued research and for developing environments for commercial use. One variable to consider in such empirical studies is that of different user groups. There may well be differences between cultures and sub-cultures in response to realistic versus iconic animated agents (c.f. O'Neill Brown, 1997; Baylor et al., 2003).

Learner/user diversity

As repeatedly indicated above, the field needs systematic research of differences between groups of people in attitudes and reactions towards virtual social characters in general, as well as towards particular instantiations of virtual social characters.

That there *is* variability in how virtual social characters are received by learners has repeatedly been demonstrated. Indeed a straight-on application of research results so far would be to convey knowledge of this state of affairs to designers of character enhanced learning environments. On such a general level, two kinds of design solutions could, furthermore, be suggested. The first solution accounts for the fact that some people but not others seem to appreciate virtual characters. It consists in offering both character enhanced and characterless alternatives. Paraphrasing Laurel (1997) on 'good interfaces': '[good learning environments] allow for more than one way of doing things. Only users who want to use agents should have them, others should have other choices' (p. 209). The second design solution provides room for variation and choice *within* the framework of character enhancement. An example is Hietala and Niemirepo's (1998) teams of teacher and learner companions that the student can choose from. The different companions have different levels of competence, personalities, voices and ways in which they interact. Another example is André and Rist's (2000) presentation teams, with multiple presenters with complementary characters and role castings. These different characters may to some extent account for the different interest profiles of a diverse audience. There are also pedagogical benefits in letting different characters present different and incompatible points of view, pairs of arguments and counter arguments, or alternative conclusions and suggestions. A further merit of this kind of design solution is that it acknowledges both the idea that socio-communicative aspects are essential for learning, and the idea that it is individuals, with varying minds, that bring about socio-communicative phenomena in all their richness and multitude.

But we still need to be better informed on *what differences* between groups of people are relevant in a certain context, in order to provide an adequate set of character strategies, roles, looks, etc. to choose from. In order to reach this, systematic studies of parameters such as age, culture, gender, learning styles are required.[12] For instance, in studying the effects of different roles and strategies, and effects of the visualization of characters - as mentioned above - we need to chart out *for which* learners increased motivation and sense of ease and comfort with learning environments can be established.

Repeated interactions over extended periods of time with character enhanced systems

Finally, efforts to conduct longitudinal studies would strengthen the research field and its applicability. It is not wear-and-tear-systems that constitute the vision and provide the impetus for the work on character enhanced learning systems, and the questions and answers that are of pedagogical interest are not to be found in one-time or short-term interactions between a student and a system.

One may not have to go to the other end of the time scale, towards the vision that Chou et al. (2003) present as 'the creation of a lifelong learning companion, one that is like a friend and stays with a student from childhood to adulthood' (p. 266) but there is a large time-scale spectrum in-between. Bickmore (2003) sets an example in his pioneering study of students who use the Laura system on a daily basis during several weeks.[13] Notably, this is also a study where a well-balanced combination of quantitative and qualitative research methods is applied.

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[12] In contrast to only addressing such issues as an aside to a main study.

[13] Bickmore (2003) himself suggests, however that the study should be repeated over a longer period of time with a much larger population

However longitudinal studies in the field of character enhanced learning systems are resource-demanding. They cannot be conducted on the basis of a dummy environment but require a system that is sufficiently developed and sufficiently rich to be able to stand up to longer time use. For one thing, too much repetitiveness in interaction must be avoided, something that Bickmore (2003) emphasizes as one of the main challenges for the development of pedagogical agents. He underlines that 'several subjects said [the repetitiveness in interaction with the exercise coach Laura] had a significant negative impact on their engagement with the system and motivation to exercise' (Bickmore, *ibid*., p. 192). Nevertheless, the field is calling for more long-term interaction studies.

Hopefully we will see increased possibilities to re-use parts or modules of character enhanced systems in different implementations and studies. Access to usable freeware is likely to increase. And researchers working on studies where for various reasons it is not feasible to work longitudinally, may nevertheless contribute by discussing possibilities to extend the studies in question to a 'repeated interactions situation'.

Research agenda in a longer term perspective

It would be unwise to single out any particular research issues or approaches as more relevant than others in a long term perspective and attempt to guess which lines of research will contribute more than others to future successful learning environments. With this caveat, I nevertheless want to highlight two of the possible benefits of character enhancement discussed in the article: that of obtaining smoother communication and that of fulfilling the need for deeper social relationships in learning. Both proposals are associated with the idea of emulating human-human interaction and human-human relationships, and related research is clearly design and development oriented. It is also often visionary and acknowledges the fact that the systems built today are only prototypes, or belong to the very first generations of computerized learning environments. In view of this, it seems unlikely that the role of character enhanced computerized learning environments in the short time, will depend upon the extent to which these claims are fulfilled.[14] On the other hand, the outcomes of these lines of research may have a major *long-term* impact on the fate of computer based learning environments. Given the high priority that pedagogical theory gives to social and communicative components of learning, the extent to which it will or will not be possible to provide socially rich, deep, smooth and natural communicative processes in computer based learning environments, may turn out to be decisive. With a less successful outcome, computer based learning may remain what it is today for many educators and students: a sometimes practical choice, yet a kind of learning that is far from the real thing, namely human face-to-face learning. Character enhancement will then continue to be mostly an ornamental addition to jazz up this second choice, and cheer up (some) learners. With a more successful outcome, character enhancement may indeed help computer supported learning develop into a genuine virtual alternative to human face-to-face learning environments.

[14] And be affected by corresponding research.

Acknowledgements

This work was partially supported by a research grant from the Swedish Science Council (Vetenskapsrådet). I also would like to thank three anonymous reviewers for highly valuable comments on a previous version of this paper. Likewise, I am grateful for valuable suggestions from Christian Balkenius, Petra Björne and Annika Wallin, all at Lund University Cognitive Science and Magnus Haake at the Department of Design Sciences, Lund Institute of Technology.

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