

Cyber Enigmas? Passive detection and Pedagogical agents: Can students spot the fake?

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Abstract

This paper presents a study that was undertaken to examine human interaction with a pedagogical agent and the passive and active detection of such agents within a synchronous, online environment. A pedagogical agent is a software application which can provide a human like interaction using a natural language interface. These may be familiar from the smartphone interfaces such as 'Siri' or 'Cortana', or the virtual online assistants found on some websites, such as 'Anna' on the Ikea website. Pedagogical agents are characters on the computer screen with embodied life-like behaviours such as speech, emotions, locomotion, gestures, and movements of the head, the eye, or other parts of the body. The passive detection test is where participants are not primed to the potential presence of a pedagogical agent within the online environment. The active detection test is where participants are primed to the potential presence of a pedagogical agent. The purpose of the study was to examine how people passively detected pedagogical agents that were presenting themselves as humans in an online environment. In order to locate the pedagogical agent in a realistic higher education online environment, problem-based learning online was used. Problem-based learning online provides a focus for discussions and participation, without creating too much artificiality. The findings indicated that the ways in which students positioned the agent tended to influence the interaction between them. One of the key findings was that since the agent was focussed mainly on the pedagogical task this may have hampered interaction with the students, however some of its non-task dialogue did improve students' perceptions of the autonomous agents' ability to interact with them. It is suggested that future studies explore the differences between the relationships and interactions of learner and pedagogical agent within authentic situations, in order to understand if students' interactions are different between real and virtual mentors in an online setting.

Keywords

Pedagogical agent, autonomous agent, problem-based learning, chatbot, passive detection

Background

The use of pedagogical agents has been increasingly adopted, adapted and tested in educational settings and the research is increasingly indicating that they are of value as mentors and guides for students. However, the research to date has not yet drawn clear distinctions between applications across disciplines and in difficult and sensitive settings (Heidig & Clarebout, 2011). In higher education the use of pedagogical agents has shifted from predominantly instructional and informational roles to those of tutors, coaches (Beaumont 2012) and learning companions (Kim & Baylor, 2006; Kim & Wei, 2011; Kim & Baylor, 2015). More recently, research has explored the social interactions of pedagogical agents and students, considering the humanistic qualities of agent-student interaction and focusing on the realism of the pedagogical agent and agent appearance (Kim & Baylor, 2015). Evidence has shown that many users are not only comfortable interacting with high-quality pedagogical agents, but that an emotional connection can be developed between users and pedagogical agents, resulting in a more positive engagement experience. Hasler, Touchman and Friedman (2013) found, in a comparison of human interviewees with virtual world pedagogical agents (in non-learning situations), that

pedagogical agents and human interviewees were equally successful in collecting information about their participants' real life backgrounds. Pedagogical agents, being neither human interviewees nor text-based surveys, therefore pose an interesting opportunity for the educator seeking to facilitate student discussion. However, as Liew et al (2013) note, the issues surrounding agent design remain complex. Early studies focussed more on the technology than affective issues (de Rosis et al., 2004) and later studies explored agent stereotyping (for example, Moreno & Flowerday, 2006; Kim & Wei, 2011). However, two recent studies have used pedagogical agents rather differently. Beaumont (2012) argues that problem-based learning (PBL) requires students to use self-regulated learning which invariably results in students asking facilitators for frequent guidance. As a result he designed a web-based intelligent tutor system to provide guidance, which when utilised by students, helped them to improve their reading and analysis of the PBL scenarios, leading ultimately to improving both their understanding of the scenario and their ability to develop effective personal and group learning objectives from that scenario. Hyashi (2012) investigated how a pedagogical agent could be used to help students to explain concepts to one another – a capability that is very important. Students were required to explain a psychological concept to other students through an online chat system. The pedagogical agent was used to provide feedback and suggestions to facilitate conversational interaction. The findings indicated that the pedagogical agent could help to improve both students' explanations and their understanding of the concept explained. Thus it would seem that both of these studies essentially focused on improving student engagement with learning and facilitating deep, rather than surface, approaches to learning. However, although Beaumont (2012) used pedagogical agents in PBL, as yet research has not been undertaken to examine whether students can passively detect an agent presented as another student.

Study rationale

This study is novel and ground breaking, as to date there is little, if any, research in this field that explores the detection of autonomous agents, especially in an education setting, nor in using autonomous agents in the context of problem-based learning online (PBLonline). Earlier work (Conradi et al., 2009; Ng et al., 2014; Savin-Baden, Tombs, & Bhakta, 2015; Savin-Baden et al., 2013) was used as a design frame and to underpin this current study. The research question was to consider: How do people passively detect pedagogical agents that are presenting themselves as humans in an online environment? Detection of pedagogical agents appears to be significantly influenced by whether it is a passive detection task (i.e. the user is not expecting a pedagogical agent), or an active one (the user is expecting the possibility of pedagogical agents). Other factors such as perceptions of gender, race, age, and context also appear to affect detection rates. The research built on previous work on live interaction with sophisticated pedagogical agents (Beaumont, 2012; Savin-Baden et al., 2013; Savin-Baden et al., 2015), but focussed it on using passive/active detection tests and in a more social setting with human and pedagogical agents. The initial concept was to base the interactions around a suitable study topic using PBLonline, so as to give an initial focus for discussions and participation, but without creating too much artificiality. PBLonline is defined here as students working in teams of four to six on a series of problem scenarios that combine to make up a module or unit that may then form part of a programme. Students are expected to work collaboratively to solve or manage the problem.

Methodology and methods

The study used a comparative mixed method design and adopted maximum variation sampling (Patton, 1990) in order to achieve the widest view possible from a diverse range of participants. Students were recruited from a higher education institution and a further education college, who were asked to participate on the basis of being part of a trial into the use of PBLonline.

Design

This study was designed with a distinct boundary between the research as a study and the experience of learning through PBLonline. The study sought to examine the possibility of detection of a pedagogical agent through PBLonline (which was not linked to students' course work or assessment). The mixed methods study was undertaken using a repeated measures design with the type of detection being manipulated. Participants worked online in groups of 4 or 5. The evaluation was undertaken by using a comparative design. Each group undertook the passive scenario first and then the active scenario. A crossover design was not feasible due to the nature of the passive test; had the active scenario been undertaken first it would have been problematic trying run the passive detection task as participants would have become aware of the presence of autonomous agents in the study. The study comprised two different weeks, the first was the passive detection phase in which students

undertook PBLonline but were not informed about the autonomous agent. There was then a gap of 4-5 weeks in order for students to continue with their studies, as well as have time to consider whether they wished to be involved in week 2. Week 2 was the active detection phase, where participants were told that there may be a pedagogical agent in the group. During each week participants engaged with one scenario over 3 sessions of 1 hour.

Procedure

Prior to commencing the sessions it was explained to the participants that the research question concerned the effectiveness of PBLonline, and that they would be asked to try out and evaluate two PBL scenarios, one per week. Informed consent was obtained from participants prior to the start of the study and their participation. Before the start of Week 1 sessions, participants were also asked to complete a demographic information questionnaire. A total of 217 students expressed initial interest in participating with this research, and of those who subsequently consented formally to take part in the research a total of 42 students actually participated. During Week 1 participants were unaware of the autonomous agent's presence within the PBL sessions. In Week 2 participants were made aware of the possible existence of a pedagogical agent before the first session. The activities were broken down into three sessions over the week, outlined below:

Week 1 (Passive) – 4 to 5 students, 1 pedagogical agent, 1 facilitator

- Session 1 - The key focus of this session was for the facilitator to introduce the scenario and help guide the participants into working out what they needed to learn in order to solve or manage the problem.
- Session 2 - Second online synchronous PBL session, where facilitators helped participants to discuss the uploaded information and to assess whether they had sufficient information to solve or manage the problem.
- Session 3 - Final online synchronous PBL session where the group worked together to bring their information together and created an action plan to solve or manage the scenario. After the final session students were asked to rate peers using a short questionnaire.

Week 2 (Active) – 4 to 5 students, 1 pedagogical agent, 1 facilitator

During Week 2 the structure of the sessions were the same as with Week 1, but with a different scenario as the basis for the online discussions. The key difference during Week 2 was that all of the participants were primed to the fact that there might be a pedagogical agent taking part in the sessions.

Ethics

Ethical clearance was gained from the University ethics committee. The deception was necessary in order to address the passive detection case (i.e. how well do people passively detect autonomous agents that are presenting themselves as humans in an online environment, when they are unaware of the potential presence of such an autonomous agent).

Data collection and analysis

Qualitative data were collected via semi structured interviews. In Phase 1 data were collected by undertaking 8 semi structured interviews before the students had been informed that there was a pedagogical agent in the chat room. A further 10 semi structured interview were undertaken at the end of Phase 2 when students had been informed there was an pedagogical agent was in the chatroom. Interpretive interactionism was adopted to analyse data to focussing on key issues and themes that emerge from all data and sought to answer the following questions: What is being said and understood here? What are the basic preoccupations of this text and how are they manifest? What is unusual here? What do these texts reveal about issues of human and pedagogical agent interaction?

Quantitative data were collected via a peer feedback questionnaire where participants could rate each of the other members of their group on 9 different criteria (Participation, Time Management, Focus on the Problem, Undertaking tasks, Collaboration, Sharing of information, Engagement on discussion board, Previous knowledge of other participants, Contact with other participants outside the PBL sessions). At the end of Phase 2 the questionnaire examined participant perceptions of the pedagogical agent and also what they felt were 'tells' that alerted the participant to the presence of the autonomous agent.

Findings

Data from the study aimed to explore the differences in passive and active detection rates of a pedagogical agent within a chatroom, but in fact few students detected the agents.

Quantitative findings

The findings from the Week 1 and Week 2 questionnaires suggests a number of key areas that would need to be addressed to improve the ability of an pedagogical agent to go undetected:

- Reduce repetition of phrases
- Improve the ability to give responses that are appropriate to the context
- Expand the bank of 'Explanations' for responses to help explain and provide the ability to give opinions.
- Develop techniques that help give the illusion of the Autonomous Agent, either in general or by answering a particular statement or question.

Week 1 Questionnaire

During the Week 1 sessions, no participants indicated that they were aware of anything untoward about any of the others who were taking part in the sessions and did not alert the facilitator to any suspicions they may have had. Individuals' evaluation of humans (mean) were compared to that of the pedagogical agent (N=31) using the Wilcoxon signed rank test, since the data did not meet the assumptions required for parametric tests; corrections for multiple comparisons were made using the Holm-Bonferroni method. The results suggest that participants rated the pedagogical agent significantly worse on Participation ($Z=2.861$, $p=.004$, $r=.363$), Time Management ($Z=2.538$, $p=.011$, $r=.322$), Focus on the Problem ($Z=3.701$, $p=.0002$, $r=.470$), Collaboration ($Z=3.234$, $p=.001222$, $r=.410$), Sharing of Information ($Z=3.202$, $p=.001365$, $r=.410$) and Engagement in discussion ($Z=3.943$, $p=.00008$, $r=.500$). This suggests the pedagogical agent was perceived as being an individual who lacked engagement and focus with the problem at hand as evidenced by their poor scores on *participation*, *engagement* and desire to take on tasks. Furthermore, the participants felt the pedagogical agent did not share what they learnt or worked well with others in the group. Furthermore, negative aspects of behaviour were generally attributed to the covert pedagogical agent being an obnoxious, uncooperative and lazy 'student' (feedback after Week 1 sessions).

Week 2 Questionnaire

During week 2 sessions the participants were aware of the presence of the pedagogical agent and were asked to alert the facilitator of the sessions if they felt they had identified the pedagogical agent. Three participants identified the pedagogical agent and informed the facilitator during week 2 sessions (one incorrectly). The remaining participants correctly identified the pedagogical agent when completing the questionnaire after week 2 session ended. Data from the week 2 surveys suggested a number of key factors and 'tells' that helped to identify the autonomous agent. These included excessive repetition, no opinions relating to the topic being discussed and the inability to effectively direct questions at individuals within the group discussion. When asked to give examples of instances which gave the pedagogical agent away, the data suggests instances where the pedagogical agent had behaved oddly (e.g. repetition or lack of ability to explain). However, some examples were provided where participants perceived the pedagogical agent to be more like a real person, and on many occasions these raised doubt as to the actual identity (e.g. referring back to a statement the participant had said or contributing to the conversation).

The last component of the questionnaire required participants to rate a number of factors (1 less to 10 most) that were helpful in identifying the pedagogical agent. The majority of participants considered the following two statements to be important indicators of a pedagogical agent. The first item 'What it said was not related to what the previous person said' (88% agreement), suggests an important distinction between the Human and the pedagogical agent was the ability to understand the meaning of the current topic of conversation and respond with a statement that was appropriate to the specific topic or question rather than to the over arching question of the session. The second item 'It didn't refer much to what other people were saying' (75% agreement), suggests that being able to respond to comments made by others is important and helps dialogue flow naturally. The Autonomous Agent's ability (or lack of) to identify the current topic of discussion accurately enough may have resulted in responses that were unrelated to those being written by the Human participants. A number of issues

were less of concern or importance to the participant and these were predominantly related to the style of the responses e.g. spelling, sentence complexity and length. Furthermore, it would appear that the responses were viewed as being factually correct and not very evasive.

Qualitative findings

Qualitative interviews elicited a number of themes relating to language genre, the ‘tells’ that gave away the agent and the apparent human characteristics of the autonomous agent.

Theme 1 Language genre

Social structure is unintentionally recreated in day-to-day social action and it was evident that students’ assumptions about language functioned in ways that supported and sustained existing structures and practices. Thus the genre(s) associated with interaction with the autonomous agent reflect the rules and procedures deployed in the construction of discourse. The interruptions to these norms were confusing and irritating to the students. The students rationalised this confusion in Phase 1 assuming that there was a linguistic problem somewhat similar to conversations with an overseas student. In Phase 2 some, but not all, of the students still assumed the agent to be a human overseas student; others drew the conclusion that communicational shortcomings identified that student as the agent. Students all noted that there was something troublesome about the pedagogical agent and whilst a few them wondered if there was some kind of technological problem, no one in Phase 1 considered the possibility that there might be an pedagogical agent in the chatroom, Tim explained:

With the first scenario about the students; I actually thought that his first language might not have been English. That’s... and that... you know, you know what I’m talking about? I thought maybe he’s speaking... because sometimes, you know, somebody... a language isn’t their first language, everything they’re saying is correct and it makes sense, but sometimes it just wouldn’t be how I would... I would say. (Tim)

However, it was evident too that genres here were not only produced unconsciously but were also the result of explicit actions and goals. Thus the text of interaction with the pedagogical agent here was a genre of rhetoric, medium and outcome. For example, there were ideological and procedural assumptions in terms of certain plots and storylines being more acceptable than others, and also that online conversation should be carried out in particular ways.

Theme 2 Bot tells

The notion of a ‘tell’ used in poker is a helpful metaphor that reflects the characteristics that resulted in the agent being revealed to the students. In poker there is an assumption that it is possible to pick up cues about the other players’ hands. Here it is used to illustrate the idea that in online settings humans use conversational cues in order to read other people, and in learning contexts to understand the norms and behaviours implicit in online groups. The three main tells were the agent:

- Not picking up changes in conversational moves
- Delivering confused utterances
- Providing inconsistent responses

Theme 3: Human characteristics

Many students attributed human characteristics to the pedagogical agent and some became highly irritated by it. One student even reflected that he had, initially in Phase 1, been quite rude to him assuming he was just a very idle student:

I just thought it was a git. I thought it was someone who was very obnoxious, very ignorant, kept putting things in really pedantic spelling, kept repeating themselves, didn’t include themselves in the discussion, very much a lone player in this. They didn’t engage in discussion. They knew what they were talking about and didn’t bother talking to us. (Daniel)

Despite several students being concerned about the pedagogical agent confusing other group members and providing responses that were inappropriate, for one student the pedagogical agent was seen as a useful member of the group. Lynn thought the pedagogical agent was an effective group member and suggested that, like her, he was shy. This equating of her own shyness with that of the pedagogical agent seems to indicate that she was

less suspicious of it since she saw in it a characteristic of herself. Mirroring or projection normally takes place in face to face settings but it could indicate in this study that students who identify with the pedagogical agent are less likely to detect the pedagogical agent. Lynn explained

Lynn: Nikos (the autonomous agent) was probably one of the other better people to actually get involved with and we had some good discussions. I think about it and from what we said he had quite a similar opinion to me.

Interviewer Who do you think worked the most and perhaps who wasn't always working that well?.

Lynn: It seems like it was mostly me and Nikos , he was shy, like I said,

Thus it would seem that the perceived similarity of the pedagogical agent to a human potentially does in some cases reduce sensitivity to the fact that the pedagogical agent is not real. This has implications for the types of relationships being built between the pedagogical agent and the user. Work by Reeves and Nass (1996) suggested that humans engage with media similarly to the ways in which they interact with other humans and other research showed that rules of politeness apply when humans interact with computers (Nass, et al 1999). This was evident in this study not only by students attributing characteristics to the agent (such as shyness and arrogance) but also finding themselves feeling sorry for the agent and then realising the inappropriateness of this response. It was evident that students saw their response to the agent as paradoxical, recognising the pedagogical agent whilst at the same time attributing social human characteristics to it and responding. However, whilst students humanised the agent they also became frustrated that the agent did not follow language conventions or social norms (even when they knew it was an agent).

Discussion

The ways in which students positioned the agent tended to influence the interaction between them. Thus those who assumed the agent was an incompetent student ignored him and those who believed he had language difficulties felt sorry for him. Students' positioning of the agent – as shy, arrogant, confused, was, in the main a mechanism used for rationalising the feeling that something was awry or uncanny. Whilst the original studies on the uncanny valley effect, (the theory which posits that as virtual characters approximate human appearance they become distracting) were associated with visual appearance (MacDorman, et al., 2009; Mori, 1970) it is evident that there was a cognitive and psychological uncanny valley effect experienced by students in this study. Turkle (2010) has suggested that people's desire to engage with robots has a sense of the uncanny. This is because, for some, engaging with robotics offers people opportunities to connect with something emotionally and feel supported, even loved, without the need to reciprocate. However, student willingness to disclose sensitive information to chatbots has been attributed partially to those chatbots being almost like a person (Savin-Baden et al., 2013). One of the issues in this study was that the agent was focussed mainly on the pedagogical task and this may have hampered interaction with the students. Perhaps inclusion of more social interaction responses and frame factors may have made it less noticeable. Although learning in online spaces brings a sense of arriving and departing without actually doing so, there remains relatively little relaxation of the coded practices of conversations in these spaces. Yet in the second scenario it seemed that some of the non-task dialogue improved perceptions of the autonomous agents' ability to interact with the students.

Whether we are cyborgs or not, our existence is augmented, and our responses to 'machines' increasingly illustrate that we are prepared to trust them and reveal sensitive information to them (Haraway, 1991). Almost 20 years ago the term thanatechnology (now often referred to as 'thanatology') was instituted by Sofka (1997), to represent this desire to preserve one's soul and assets digitally after death and it has since been developed further by Sofka and Gilbert (2012). There have also been cases where people receive 'beyond the grave' updates from dead friends (McAlear, 2011; McCall, 2013), and companies dedicated to creating digitally immortal personas (LivesOn, 2015). Pedagogical agents could be used for a whole range of activities, from creating some form of digital immortality, to actively being virtual mentors, virtual tutors or helping students to learn communication skills. It is clear from earlier work (Savin-Baden et al., 2015) that learning and engagement using pedagogical agents provides opportunities for displaying, testing and responding to the emotions of self and others in a safe and non-threatening environment. This can be either subject specific emotional skills (for example empathy), or non-subject specific in the general sense of emotional intelligence. Furthermore, the perceived realism of an agent, both in terms of its appearance and conversational style, can negate the potential effectiveness of agents being used long term. Globally there has been increasing interest in

the concept of virtual people and virtual human artificial intelligences. The US Military has had a Human Dimensional Modelling (HDM) in Virtual Battlespace 2 and a Virtual Dialogue Application for Families of Deployed Service Members project (OSD09-H03) and NASA has had “Extra-tars” and “surrogatars” in its ANSIBLE project to support astronauts on long duration missions. Whilst current (2016) technology is still some way short of substantively and consistently passing an unmodified Turing Test, such an achievement is likely within the next decade – which would then open the way to the fuller exploitation of the technology. Whilst the creation of a physical virtual human android is still a long way off, the creation of digital human avatars, even if not actually sentient or “intelligent”, is far more achievable and could be highly useful.

Recommendations and Future Research

The qualitative results of the study provide insights into how pedagogical agents interact with students in real educational settings. However, it was clear that several important improvements could be made:

- The use of more vernacular phrases: students felt the agent was too grammatically correct and therefore the use of local and informal language would have made the agent less detectable
- The inclusion of humour by agent: as the agent was focused on the pedagogical task humour was not included, but it could have been and would be an improvement
- The insertion of positive comments and statements by agent to students. A study by Baylor (2011) suggests that having an agent that demonstrates positive attitudes towards the task and the desired levels of performance is helpful for learners, particularly in situations where they are a novice.
- The inclusion of frame factors to establish common ground between the students and between the agent and the students. If the agent were able to discuss issues such as travel, accommodation and assessment this might also help to reduce detection of the agent.

Based on the results of the study, future research should examine the feasibility of virtual mentors that can act to support students. Future research might therefore seek to explore:

- How a virtual mentor can be created for every student that can act as a point of information, or advisor, throughout their lives.
- Exploration is needed into technology shaped by student-agent interaction, agent roles and students' perspectives about ways in which agents could support learning
- Examination of the impact of agent use of non-task dialogue in improving or hindering learning.

Conclusion

The results of this study contribute to the literature examining detection, as the study focused on situations where participants, primed or not, were able to directly interact with a pedagogical agent. It is expected that findings from this study will support the notion that passive detection accuracy can be increased through direct interaction with the pedagogical agent. The results of the active detection tasks are not expected to have significantly higher false positives as a result of the direct interaction with the pedagogical agent.

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