Designing Virtual Agent-Based Models For ICT Courses: The Impact On Developing Student Skills

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Abstract

The aim of this study is to compare two pedagogical models: the Virtual Agent Team-Based Model, which is implemented in an online environment that offers a more varied and collaborative form of interaction, and the Text-Based Conversational Virtual Agent Model, which is implemented as an interactive chatbot that provides predetermined textual responses. In addition to investigating the effect of two pedagogical models of virtual agent robot use in ICT courses. Such a model aims at achieving interactions with virtual agents, suggesting a topic from the chat script, auto-playing, and replying to improvements and chat customization. Moreover, it links the virtual agent with more than one application that can support students' skills in acquiring their educational content for chat and sharing scripts and checking students' performance in longer interactions. The paper is based on mixed research methods that were used to study the impact as follows: The development method is used in designing the e-learning environment, a quasi-experimental research design for conducting the research experiment. The findings of the study provide evidence of the effect of virtual-agent models in supporting students' learning within electronic learning environments. These findings have significant implications for instructional designers and educators seeking to influence virtual agent technologies to enhance learning outcomes, suggesting that collaborative, socially rich configurations should be highlighted over individual avatar-based models where the development of interactive programming skills is a major educational impartial.

Keywords: Pedagogical models, virtual agents, robots, programming skills.

Introduction

In the current digital age, technology has appeared and increased the ease and ability of individuals to perform activities and tasks. This happened because of the changes that emerged in the mechanisms of communication between individuals and the creation of new tools that did not exist before, such as the changes that occurred in the development of machines and devices, the spread of the Internet and network systems, and the students' access to such technologies. It is necessary to modify the used methodology and use tools that suit the requirements of the age. (Beer, P., & Mulder, R. H., 2020). In addition, it should support 21st-century learning skills, especially since the environments are designed to allow students to learn wherever and whenever. Such services emerged because alternative methods of communication match the types of human interaction that take place in the real environment. This requires guidance to identify the alternative technologies that can help change the attitude of student learning, especially in programming. (Autor, 2015)

Traditionally, social interaction research has focused on fully embodied conversational agents or robots. For a period, the two aspects began to increase their 'agents' social interaction capabilities using intelligent and pervasive environments, developing different agent systems for social interaction along the way, such as the Milgram VR series, depending on the degree to which they are embodied in a physical, virtual, or mixed reality environment. It must display such systems in a logical step representing embodied agents in the physical and virtual world (Holz, et al., 2009, p. 83). One of the new techniques in video lectures is to show slides with a video clip of an instructor explaining the slides. Replacing the teacher with a robot or digital device could significantly reduce production time and cost. Thus, the impact of a digital agent or robot on the learner and agent-based alternatives to the talking head should be evaluated through an experiment comparing human and agent lecturers in an online training course (Li, et al., 2016, p. 1222). There is a set of open-source tools designed to help researchers, game developers, and robotics experts integrate an algorithmic model of emotion and decision-making into their work and human-robot interaction (Mascarenhas et al., 2021).

In fact, there is no single, common, or best way to introduce computer science and its technologies into the curriculum. Despite the many benefits demonstrated in the literature, neither computer science nor robotics has been fully integrated into the classroom as part of a standard curriculum (El-Hamamsy. et al., 2021). In addition, there are scarce documents detailing the methods used, as few countries are evaluating their initiatives and/or communicating their results (Balanskat & Engelhardt, 2015). Basically, 21st-century robots are considered efficient for machines and a harbinger of unemployment for humans, where robots with their cinematic image are close to human forms and earn applause for their slow attempt to spell letters and words. He stated that the benefits of a robot revolution will outweigh the impacts on the manufacturing sector and low-cost labor. The robot engages offices and rises the ladder of professions such as law, medicine, engineering, architecture, and financial analysis (Fakihi, 2014, p. 24).

Although there are systems and tools that can be used to provide educational environments supported by virtual environments and robots, now such environments do not have an educational conceptual framework for their interaction.

Accordingly, the research problem can be identified as follows. There is a need to determine the most appropriate two pedagogical models of virtual agents' robots in programming courses to develop the scientific aspects of the information and communication technology (ICT) course and the practical content of programming. The current research sought to build two models to provide the content for a course that supports two virtual agent robot models, measures their effectiveness in overcoming these problems, and determines the most effective of the two models according to the environment used.

Accordingly, the research problem can be addressed by answering the following question: What is the effectiveness of the two pedagogical models of virtual agent robots in ICT course with a focus on programming skills in the curriculum-related preparatory stage? This question was divided into the following sub-questions:

What are the mechanisms of presenting virtual agent robots in pedagogical frameworks using a model set according to procedural steps?

RQ1: How can the design of two pedagogical models of virtual agent robots in an ICT course be improved?

RQ2: What is the effect of designing two pedagogical models of virtual agent robots in developing skills of an ICT course for middle school students?

In conclusion**,** the research objectives can be summarized as follows: Identifying the effectiveness of designing two pedagogical models of virtual agent robot programming courses and measuring their effectiveness on the programming skill content for middle school students. Identify the effect of an electronic environment (multi-agent) in developing programming skills for students in the preparatory stage and improving their attitude toward the environment. Finally, determinin**g** the most effective of the two models in presenting the skills aspect of programming for middle school students.

Literature Review:

Virtual Agents and Pedagogical Robots

Over the recent years, virtual agents and pedagogical robots have attracted many researchers due to their potential to improve the accessibility of pedagogical content and learning outcomes in a variety of learning situations to support learner engagement (Li et al., 2016; Graesser et al., 2005). In the same way, educational robots have shown great potential as both virtual and physical learning mediators, especially in technology-oriented fields where experiential, hands-on learning is crucial (Belpaeme et al., 2018). Moreover, it has been suggested for virtual agents. it is not the visual presentation of the character itself, but its pronunciation and the teaching method embedded in its use that leads to improved learning (Krämer & Bente, 2010), especially as so-called "embodied conversational agents." In addition, human-like robots facilitate human-technology interaction in reference to the unique human capabilities of interpersonal communication and information processing (Vogeley & Bente, 2010). This requires collective efforts to expand understanding and perspectives on how robots and virtual agents influence the distinctive technical and experimental challenges of designing and conducting agent interactions (Yadollahi et al., 2021). A virtual agent, sometimes called an intelligent virtual agent, or chatbot, is software that uses written rules, based on applications of artificial intelligence, to provide automated assistance for individuals. Virtual agents are generally employed by marketing or promotional institutions in private customer service to satisfy routine customer inquiries or deal with simple problems without human intervention. Incorporating educational content into their function may have more organizational mechanisms, because the interaction between the instructor and students may require more nuance than responding to a customer who has a complaint about a product or a simple inquiry. Several studies stated the need to develop a model for reforming computer science education with robotics (Webb et al., 2017); therefore, an educational framework for implementing virtual agent robots was developed. It requires an empirical understanding of the robots, their interaction with humans, and how they can achieve assured outcomes in education (Fitrianie et al., 2019). Many applications of virtual agent robot software in various activities was discovered, starting with Internet applications such as searching and retrieval of information, monitoring, and email management. It has a set of characteristics that distinguish it from traditional programs (Abdel-Gawad, 2006, p. 3) as follows:

- **Anticipation**: Agents demonstrate goal-directed behavior by taking the initiative and taking action to achieve their objectives rather than just reacting to their environment.
- **Adaptation**: Agents should be able to engage with the external environment and gradually enhance both their performance and that of the user.
- **Collaboration**: Agents must be able to work jointly with other agents through agent communication to accomplish a common goal. Agents may share knowledge and learn experiences in this process. However, the concept of collaboration also refers, according to some studies, to agents cooperating with users and not just with agents. The concept of agents collaborating with users means that agents do not blindly obey orders but can modify requests.
- **Mobility**: Agents can move from one machine to another and from one network to another and through different programs and structures within the network to complete their tasks.

Li (2015) analyzed 33 experimental research works to evaluate human interactions with virtual and real robots to investigate the effects of physical presence. Robots that are physically present in the user's environment are more persuasive and positive than those that are digitally displayed on a screen, either as an analog virtual character or as a video feed of the same robot, according to a qualitative evaluation of the direction of quantitative effects. Additionally, when the robots were physically present instead of being displayed on a screen through video, the user performed better. Participants did not react differently to virtual and physical robots when they were shown digitally on a screen, indicating that people's reactions to robots are more likely to be characterized by physical presence than by physical embodiment. Within the same framework, Abdullah (2020) focused on educational models that are compatible with the advancement of educational technology to identify semantic discussions designed according to the learning model to develop production skills. Despite these encouraging results, avatar-based methods have also been linked to several drawbacks, such as fewer opportunities for peer interaction, a limited ability to simulate real-world collaborative situations, and possible declines in social presence in comparison to more dynamic, multi-agent configurations (Gomes de Siqueira, et al., 2021). The creation and research of team-based virtual agent frameworks as an additional teaching model have been encouraged by these constraints.

Team-Based Virtual Agent Models and Collaborative Learning

In educational technology research, team-based virtual agent models—in which several virtual agents cooperate in a common digital environment—represent a developing and theoretically rich field. Based on collaborative learning frameworks (Johnson & Johnson, 2009) and sociocultural learning theory (Vygotsky, 1978).

Collaborative virtual environments consistently deliver better learning outcomes than individual-based configurations, especially in domains requiring distributed cognition, problem-solving, and communicative competence (Dalgarno & Lee, 2010). Team-based virtual agent models have been demonstrated to successfully organize collaborative programming assignments, enable peer feedback mechanisms, and foster the development of higher-order thinking skills in the context of ICT education (Sáez-López et al., 2016).

Research by Zheng et al. (2020) demonstrated the educational benefits of socially rich virtual agent configurations by confirming that online collaborative virtual agent settings provided measurable advances in both cognitive engagement and programming skill learning among ICT learners.

The current study's investigation of the varying impacts of avatar-based and team-based pedagogical virtual agent models on student performance and engagement in ICT courses is supported both theoretically and empirically by these findings considered collectively.

Research Method

Considering the findings of the literature review and the increasing use of virtual agents as educational tools, this study sought to develop and investigate pedagogical models of virtual agents that could support students in acquiring practical programming skills. The study's main goal was to prepare middle school students to be ready for programming skills assignments. The authors used the development research method. The proposed learning environment was designed via a development-based model. Finally, the effectiveness of the proposed models in promoting students' practical skills in programming and their engagement within the learning environment was evaluated using the experimental approach during implementation and assessment phases.

Instructional Design Model

The learning environment, pedagogical models, and virtual agents were designed based on the ADDIE instructional design model as a methodical framework. Analysis, Design, Development, Implementation, and Evaluation are the five sequential related phases that form ADDIE. This model was selected because it provides a methodical process for identifying learners' needs, creating the suitable learning experiments, identifying the instructional materials and technology, developing learning environments, and evaluating its efficacy.

1) Analysis Phase:

During the analysis phase, the researchers identified the requirements for designing the learning environment and the virtual agent models. This phase included:

- Analysis of the target students, including their educational level, characteristics, prior knowledge, and technological experience.
- Identification of learning needs related to practical programming skills.
- Analysis of the prescribed programming content and determination of the concepts and skills students were expected to acquire.
- Identification of the practical programming skills and sub-skills necessary to complete the assigned programming projects.
- Analysis of the educational characteristics and functions of the virtual agents that could be integrated into the learning environment.
- Determination of the appropriate technological environment for the presentation and implementation of the virtual agent models.
- Identification of the interaction requirements between students, the educational content, and the virtual agents.

The analysis phase resulted in a clear specification of the learning objectives, content, student characteristics, required programming skills, interaction requirements, and technological resources needed for the subsequent design phase.

2) Design Phase

In the design phase, the instructional structure and components of the proposed learning environment were specified. The authors transformed the results of the analysis into an instructional design that included:

- Formulate general and specific learning objectives.
- Organize the programming content into appropriate learning units and activities.
- Determine the sequence of learning activities and practical programming tasks.
- Design the learning interactions between the student, the virtual agent, the content, and the learning environment.
- Determine the pedagogical role of each virtual agent model.
- Design the first model as a text-based conversational virtual agent, providing students with direct interaction through a simple chatbot interface and predefined text responses.
- Design the second model as a team-based virtual agent model, in which students interact within an online environment that supports broader and more collaborative forms of interaction.
- Design opportunities for participation, task completion, communication, guidance, and role-playing.
- Design the assessment procedures and instruments used to measure students' practical programming skills, interaction, and experiences. The design phase therefore established the instructional and interactional structure of the two experimental conditions before their actual development and implementation.

3) Development Phase

- During the development phase, the instructional specifications and designs were transformed into the learning environment and learning materials. The researchers developed the programming activities and implemented the virtual agent models according to the specifications established during the design phase.
- For Model (1), a simple, text-based, conversational virtual agent was developed using HTML, CSS, and JavaScript. The interface included a conversation area, a response area, and a text input field through which students could communicate with the agent. The agent was programmed to provide predefined responses to specific student inputs and to provide a default response when an input was not recognized.
- For Model (2), the virtual agent's team environment was implemented through an online platform that allowed students to interact with the learning environment and participate in a more collaborative form of interaction with the virtual agent.
- During this phase, the researchers also developed the instructional activities, programming tasks, support materials,

and assessment tools necessary for implementing the learning experience.

4) **Implementation Phase**

- During the implementation phase, students were introduced to the developed learning environment and the two pedagogical models. Participants were assigned to two experimental groups, each of which received the same programming content and learning objectives, but through a different virtual agent model.
- The first experimental group studied with Model (1): the text-based conversational virtual agent.

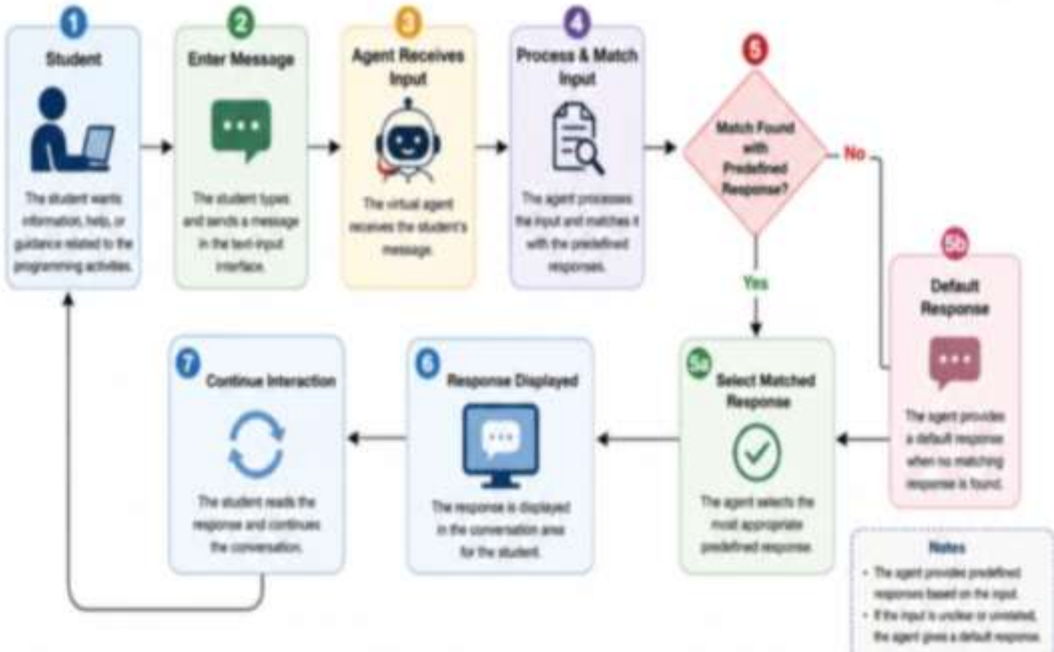

Figure 1: Interaction Flowchart of Model (1): Text-Based Conversational Virtual Agent

while the second experimental group studied with Model (2): the Team-Based Virtual Agent Model, through the online environment.

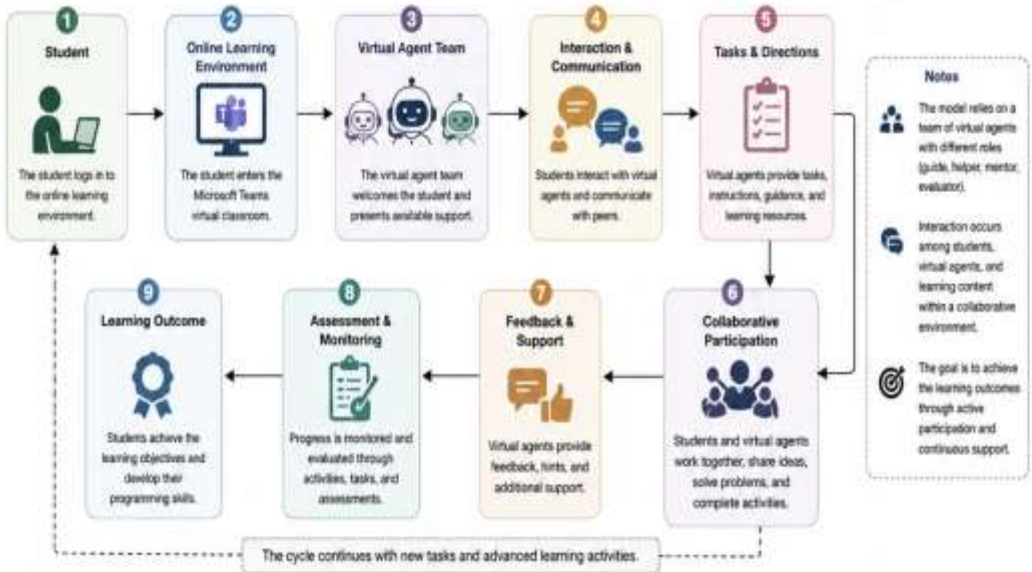

Figure 2: Interaction Flowchart of Model (2): Virtual Agent Team-Based Model

- The implementation focused on training students to acquire the target programming skills through practical activities and projects. Students had the opportunity to interact with the virtual agents, perform programming tasks, receive guidance, and participate in learning activities according to the instructional procedures designed for each model. **5.**

5) **Evaluation Phase**
   - The evaluation phase was conducted to determine the effectiveness of the proposed virtual agent models in achieving the intended learning outcomes. Both formative and summative assessment procedures were considered during the development and implementation of the learning environment.
   - The summative assessment consisted of comparing the performance of the two experimental groups using the study's assessment instruments. Students' practical programming skills were assessed using the practical performance rubric, while their interaction and participation in the learning environment were examined using the interaction assessment rubric. Additionally, students were given an interview card after completing the learning experience to identify their experiences and perceptions in the emotional, cognitive, behavioral, and motivational dimensions.
   - The results were statistically analyzed to determine the differences between the two experimental groups and to examine the effectiveness of the proposed virtual agent models.

The Experimental Design

In accordance with the independent variable and its levels, the study employed a two-group quasi-experimental pre-test/post-test design. The independent variable was the pedagogical model of the virtual agent, represented by two experimental conditions:

Experimental Gr. 1	Model (1):	Text Based Conversational Virtual Agent (Online/Offline).
Experimental Gr. 2	Model (2):	Virtual Agent Team Based Model (Online).

Table 1: The Experimental Design

The dependent variables included students' practical programming performance, interaction and participation within the learning environment, and reported learning experiences. Both experimental groups were subjected to the appropriate pre- and post-assessment procedures, allowing the authors to examine changes in students' performance and compare the effectiveness of the two virtual-agent models.

The first experimental group studied the programming content using Model (1), the text-based conversational virtual agent, while the second experimental group studied the same content using Model (2), the virtual agent team-based model, implemented through the Microsoft Teams online platform.

Both groups were exposed to the same learning objectives and targeted programming skills. The primary difference between the two groups was the pedagogical model and form of virtual-agent interaction used to deliver and support the learning experience.

Participants

The participants consisted of 30 students in the second grade of preparatory school during the second semester of the 2020–2021 academic year. The students were divided into two experimental groups, with 15 students in each group.

Summary of the ADDIE-Based Design Procedure

The instructional design process can therefore be summarized as follows:

Analysis → Design → Development → Implementation → Evaluation

Learning objectives, programming material, interaction specifications, and evaluation criteria were considered when designing the virtual-agent models due to this methodical approach. Additionally, it provided a methodical framework for comparing the two instructional approaches and assessing how well they developed students' practical programming skills and improved their engagement in the classroom.

Pedagogical Models of Virtual Agents

A conversational virtual agent (chatbot) is represented by the utilized model. Students can communicate with the agents by sending text messages and getting immediate text responses through a simple interactive digital environment. HTML, CSS, and JavaScript were used to create the agent's interactive interface, which has an input field for student messages, a section for displaying responses, and an agent title.

A set of written replies to a function. Within the code, a fundamental knowledge base was established, linking several terms or phrases that students might type to matching answers. For instance, the agent provides a set answer linked to the submitted phrase when the learner inputs a term like s "اهلا" (Hello), "اريد" (I want), or "شكرا لكم" (Thank you); the agent presents a predefined response associated with the submitted phrase. Global communication: the model also has several English responses, including "Hello," "How Are You?" and "Bye".

The interaction process, which compares the entered message with the phrases stored in the response database, occurs when the student enters a message in the input field and presses the Enter

key. The agent provides the matching programmed answer if an appropriate match is found. If the entered message is not recognized, the agent presents a default message that notifies the user that the input is not understood and offers the opportunity to utilize WhatsApp to get in touch with the environment designer directly.
Rather than being a human-like avatar or 3D visual character, the agent was designed as a basic 2D interface. Various colors are utilized within the interface to identify the primary area of interaction. The agent's title can be seen in the top section, the dialog and response are shown in the center section, and the student's text entry box is in the lower section.

Accordingly, this model can be classified as a text-based conversational virtual agent, rather than an avatar-based virtual agent. Its primary focus is on textual interaction and immediate response rather than on visual representation through a human-like or three-dimensional avatar.
From a pedagogical perspective, the model can be used to support student–agent interaction by providing immediate guidance, feedback, and responses based on predefined conversational scenarios. Furthermore, the design can be expanded by adding new questions, keywords, and educational responses to the knowledge base, thereby adapting the virtual agent to different educational content and learning objectives.

Figure 3 The User Interface of the Conversational Virtual Agent in the Educational Environment

Designers or educators can choose avatars to reflect different aspects of their different identities. They can be embodied in different cultures, conditions, climates, or environments through technological presentations, graphic accuracy, and system capabilities as well as designers' vision for the use of the system (Çakir, 2015, p. 95). The avatar is an intelligent virtual agent through which human-computer interaction can be implemented (Guerrero et al., 2019), Figure (3) the progression of the model The implementation of the proposed second model is represented by adopting and applying the concepts of virtual agents based on the Office suite giving the tools needed to create Chabot's easily and automatic frequently asked questions and business processes within the Microsoft Teams platform. Implementing bot applications without writing code works through Microsoft Power Virtual Agents, which is part of Office 365. Power Virtual Agents allows the creation of bots that can help answer students' questions Bots use chat for built-in content building blocks, trigger statements, and pre-composed bot conversations to provide special skills in programming for middle school students. The model has been implemented in the following steps: Figure (3)

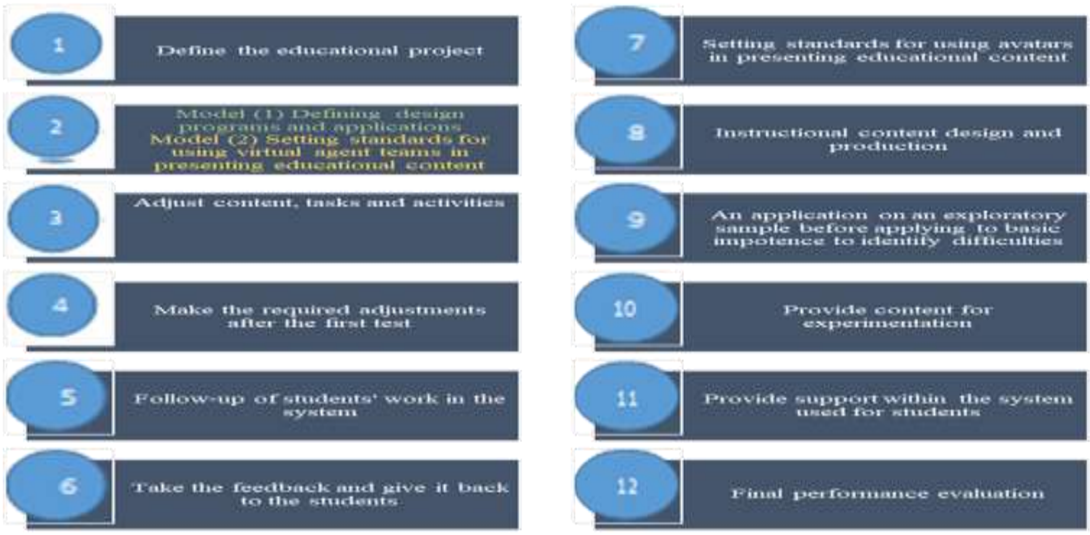

Figure 4: (Steps for implementing pedagogical models of virtual agents online/offline)

The Research Tools
The current research relied on the following tools: Skill observation card for students' performance in the course content and evaluation card in a rubric-designed environment. In addition, an interview card to determine the handling of forms.

1. Designing a skill performance card for students' performance in an ICT course and the practical aspect of programming the html language, as well as JavaScript. The card is displayed in table (2).

Table (2) the skills needed to achieve the interactive project in programming

Main Skills	Sub-Skills
Employ orders of HTML (adding field-button, choosing an alternative)	6
Explain some elements of HTML language	4
Write orders of HTML correctly	5
Recognize the basic rules for creating web page using Java Script	6
Recognize how to summon Java Script using button	6
Write significant function code properly	3
Employ the tools of Java Script in interactive project	4
Total	34

The authors presented the observation card to a group of specialists in educational and computer technology to identify the formulation of the phrases and their suitability to measure what was put forward. The correlation coefficient was 0.854, which is a statistically significant value at the 0.01 level.

2. An evaluation card for performance in the rubric-designed environment. Note the performance of students in the course content, ICT, the practical aspect within the virtual agent environment. The card consisted of table (6) main skills, followed by a number of sub-skills to ensure the interaction of learners within the virtual environment according to the skill set (participation and interaction, participation changes, providing participants with tasks and directions, speech recognition and understanding, organizing the exchange of roles in learning, participating in the context of the conversation). The expressions and their relevance. and the internal consistency was calculated by applying a rubric to a survey sample to verify the clarity of the items of the observation card on the rationing sample. The correlation coefficient was calculated, and its value was 0.868, which is a statistically significant value at the 0.01 level.
3. An interview card to determine how to deal with models. The interview card consisted of four criteria that express the learner's satisfaction in the environment after applying the experiment (emotional component, motivation to learn, cognitive component, and behavioral component). The authors presented an interview card to a group of educational technology specialists and psychologists to identify the formulation of phrases and their suitability for measurement. The validity of Alpha Cronbach's stability coefficient (0.788) was calculated, which is statistically significant at the 0.01 level.

Results

Results Related to the First Research Question

To answer the first research question, the mechanisms for presenting virtual agents in pedagogical forms and frameworks were identified and implemented through a set of procedural steps. Twelve steps were identified for implementing learning within the educational environments. These steps were designed according to specific instructional procedures to ensure the appropriate presentation and implementation of the proposed virtual-agent models for the students.

To examine the performance of the students in the first and second experimental groups with respect to the practical performance of programming skills, the students' scores were analyzed using a practical performance rubric. The means and percentages were calculated for the sub-skills associated with each main skill, and the performance of the two experimental groups was compared as presented in Table (3).

Table (3) Means and Percentages of the Performance of the Two Experimental Groups on the Practical Performance Rubric

Main Skills	Number of Sub-Skills to Be Achieved	Maximum Score per Skill	Total Skill Score	Model (1): Text-Based Conversational Virtual Agent		Model (2): Virtual Agents Teams	
				Mean	Percentage %	Mean	Percentage %
Skill 1	6	18	270	13.4	74%	15.56	86%
Skill 2	4	12	180	7.87	66%	10.94	91%
Skill 3	5	15	225	11.8	79%	12.94	86%
Skill 4	6	18	270	13.93	77%	15.13	84%
Skill 5	6	18	270	14	78%	15	83%
Skill 6	3	9	135	6.4	71%	7.13	79%
Skill 7	4	12	180	9.87	82%	11.06	92%

Note. Model (1) refers to the text-based conversational virtual agent model implemented through the interactive chatbot interface, whereas Model (2) refers to the virtual agents teams model implemented through an online environment.

According to table 2, it shows differences in the mean scores and percentages of students' practical performance across the seven main programming skills. The results indicate that the second experimental group, which studied using Model (2), achieved higher mean scores and percentages than the first experimental group across all seven skills.

The percentage differences were particularly evident in Skill 2, where the second experimental group achieved 91% compared with 66% for the first group, and in Skill 7, where the corresponding percentages were 92% and 82%, respectively. Overall, these findings indicate that students who learned through the Virtual Agents Teams model demonstrated better practical performance in programming skills than students who learned through the text-based conversational virtual-agent model.

The results indicated that students' practical skills could be improved by the virtual-agent environment's diversity and collaborative environment, particularly when the learning environment provides deeper types of interaction and engagement opportunities.

It should be emphasized that Tables (3) and (4) address two different aspects of students' performance. Table (3) presents the students' practical performance in acquiring and applying the targeted programming skills, whereas Table (4) presents their interaction and participation within the learning environment. Accordingly, Table (3) reflects the cognitive and practical outcomes related to programming skills, while Table (4) reflects the interactive and participatory aspects of learning through the virtual-agent models.

Analysis of Students' Performance Using the Rubric

To further examine the performance of the students in each experimental group while using the proposed virtual-agent model, their performance was analyzed using the practical performance rubric. The means and percentages were calculated for the sub-skills, and the performance of the two experimental groups was compared. As illustrated in Table (4) that presents the results.

Table (4) Descriptive Statistics of the Performance of the Two Experimental Groups in Interaction within the Learning Environment

Main Skills	Number of Sub-Skills	Maximum Score	Total Skill Score	Model (1): Text-Based Conversational Virtual Agent (Online/Offline)		Model (2): Virtual Agent Team-Based Model (Online)	
				Mean	Percentage %	Mean	Percentage %

Participation and Interaction	3	6	270	13.4	74%	15.56	86%
Participation Changes	3	6	180	7.87	66%	10.94	91%
Providing Participants with Tasks and Directions	3	6	225	11.8	79%	12.94	86%
Recognizing and Understanding Speech	3	6	270	13.93	77%	15.13	84%
Organizing Role-Sharing in Learning	3	6	270	14	78%	15	83%
Participating in a Conversational Context	3	6	135	6.4	71%	7.13	79%

The interaction skills assessed in the learning environment included participation and interaction, changes in participation, providing participants with tasks and directions, recognizing and understanding speech, organizing role-sharing in learning, and participating in a conversational context, as explained in table 4.

Table (4) revealed the differences as well in the mean scores and percentages of the two experimental groups across all assessed interaction skills. The results show that the second experimental group, which used the Virtual Agent Team-Based Model, achieved higher mean scores and percentages than the first experimental group, which used the Text-Based Conversational Virtual Agent Model.

In the Participation and Interaction skill, the first experimental group achieved a mean score of 13.40, representing 74%, whereas the second experimental group achieved a mean score of 15.56, representing 86%. Regarding Participation Changes, the first group achieved 66%, compared with 91% for the second group. For Providing Participants with Tasks and Directions, the percentages were 79% and 86%, respectively.

As a result, the first experimental group scored 77% in recognizing programming skills, while the second group scored 84%. The equivalent rates for organizing role-sharing in learning were 78% and 83%. Finally, the first group received 71% for engaging in a conversational setting, whereas the second group scored 79%.

In general, the results revealed that in every skill, the second experimental group consistently performed better than the first. This result indicates, compared to the text-based conversational virtual agent model, the virtual agent team-based model may provide more chances for interaction, task engagement, and role-sharing in the learning environment. The Mann-Whitney U test was utilized to assess the significance of differences between the two experimental groups' scores on the interaction assessment rubric to determine whether these differences were statistically significant. The statistical analysis's results are displayed in Table (5).

Table (5) Mann–Whitney U Test Results for the Post-Test Scores of the Two Experimental Groups

Type of measurement	Type of assessment	The groups	N	Mean Rank	Sum of Ranks	Mann-Whitney U	W	Asymp. Sig. (2-tailed)
Programming test	POST-TEST	experimental (1)	15	10.70	160.50	40.500	160.5	0.01
		experimental (2)	15	20.30	304.50			

The results of the Mann-Whitney U test, which was used to determine whether the two experimental groups' post-test scores on the programming skills evaluation differed significantly, are shown in table (5). The results revealed that the post-test scores of the experimental groups offered statistically significant results at the 0.01 significance level.

The Mann–Whitney U value was 40.500, while the W value was 160.500, with an asymptotic

significance value of 0.01. Since the significance value is equal to the predetermined significance level (α = 0.01), the difference between the two groups is statistically significant.
Furthermore, the results show that the second experimental group obtained a higher mean rank (20.30) than the first experimental group (10.70). This indicates that the students who learned using Model (2), the Virtual Agent Team-Based Model, demonstrated significantly better post-test performance in programming skills than the students who learned using Model (1), the Text-Based Conversational Virtual Agent Model. These findings provide statistical evidence that the type of virtual-agent model used in the learning environment had a significant effect on students' practical programming performance. Thus, the results support the effect of the Virtual Agent Team-Based Model in enhancing students' acquisition and application of programming skills.
The answer to Question 2

To answer the second research question and determine the extent to which students benefited from learning through the proposed virtual-agent models, the authors analyzed the students' responses obtained through the interview. The interview results were examined to identify students' perceptions, experiences, and perceived benefits after using the virtual-agent models during the learning process. The results are presented in the following section.

Results of the Interview Card

The interview card was administered after the students had completed the learning content through the virtual-agent models implemented within the electronic learning environments. The purpose of the interview was to explore the students' experiences and perceptions of the learning environments and to identify the extent to which the virtual-agent models contributed to their emotional, cognitive, behavioral, and motivational engagement with the learning process.

Table (6) Descriptive Statistics of the Interview Card Results According to the Experimental Condition

Dimensions of Learning	**Model (1): Text-Based Conversational Virtual Agent (Online/Offline)**		**Model (2): Virtual Agent Team-Based Model (Online)**	
	Students' Responses (N)	Percentage %	Students' Responses (N)	Percentage %
Emotional	12	80%	14	93%
Cognitive	13	87%	14	93%
Behavioral	10	67%	15	100%
Motivational	12	80%	13	87%
Total	**47**	**78%**	**56**	**93%**

Table (6) presents the descriptive results of the interview card according to the four dimensions of learning: emotional, cognitive, behavioral, and motivational. The results indicate that the second experimental group, which used the Virtual Agent Team-Based Model, reported higher response frequencies and percentages across all dimensions compared with the first experimental group, which used the Text-Based Conversational Virtual Agent Model.
Regarding the emotional dimension, 80% of the students in the first experimental group provided positive responses, compared with 93% in the second experimental group. For the cognitive dimension, the corresponding percentages were 87% and 93%, respectively. The largest difference was observed in the behavioral dimension, where the first group achieved 67%, whereas the second group achieved 100%. In the motivational dimension, the first group achieved 80%, compared with 87% for the second group.
Overall, the total response rate was 78% for the first experimental group and 93% for the second experimental group. These results indicate that students who learned through the virtual agent team-based model demonstrated more positive experiences across the emotional, cognitive, behavioral, and motivational dimensions than those who learned through the text-based conversational virtual agent model.
The findings further suggest that the diversity of interaction and the collaborative features provided

by the Virtual Agent Team-Based Model may have contributed to enhancing students' engagement with the learning content and their overall learning experience. In particular, the higher behavioral and cognitive responses suggest that the second model may have provided students with greater opportunities to participate, interact, and engage actively with the learning environment.

The results of the interview provided additional qualitative support for the quantitative results presented in the previous tables. While Tables (2) and (4) focused primarily on students' practical programming performance, and Table (3) examined their interaction and participation within the learning environment, Table (5) provides insight into students' experiences and perceptions across the emotional, cognitive, behavioral, and motivational dimensions of learning. Additionally, the results revealed, in comparison to the text-based conversational virtual agent model, The virtual agent team-based model was interconnected to more favorable learning experiences and better levels of student engagement. Model (1), the Text-Based Conversational Virtual Agent Model, which is implemented as an interactive chatbot that provides defined textual responses, and Model (2), the Virtual Agent Team-Based Model, which is implemented within an online environment that provides a more diverse and collaborative form of interaction, were the two pedagogical models that were compared in this study. The results also demonstrated that the second experimental group had higher percentages in every interaction dimension that was evaluated, including participation and interaction, changes in participation, giving participants tasks and instructions, identifying and comprehending speech, establishing role-sharing in learning, and engaging in a conversational setting. These results imply that the Virtual Agent Team-Based Model gave students more chances to engage, participate, interact, and communicate in the classroom.

The Mann–Whitney U test results confirmed that the post-test programming performance difference between the two experimental groups was statistically significant at the 0.01 level. With a Mann–Whitney U value of 40.500 and a significance value of 0.01, the second experimental group achieved a higher mean rank (20.30) than the first experimental group (10.70). This outcome offers statistical proof that the Virtual Agent Team-Based Model outscored the Text-Based Conversational Virtual Agent Model in enhancing students' practical programming performance.

Discussion

The study findings revealed that the two pedagogical models of virtual agents varied significantly in their ability to promote learner interaction and programming skills in the digital learning environments. The findings of related work are presented, and the experiential evidence is supported by the discussion. According to the findings, students in the second experimental group regularly performed better than those in the first experimental group in all seven major programming skills when they interacted with the Virtual Agents Teams model (Model 2) in a virtual environment. Performance percentages for Model 2 ranged from 79% to 92%, compared to 66% to 82% for Model 1, indicating a clear performance advantage associated with the collaborative, team-based virtual agent environment.

Furthermore, the results are consistent with Li (2015), who reported differences in user responses to physical robots and virtual agents depending on their mode of presentation and presence.

The results reflect the broader concept that the design and environment in which an agent is presented affect learners' engagement and performance, even though the current study did not compare real robots with physically integrated beings. These outcomes are also in line with work by Mikropoulos and Natsis (2011), who explained that, in contrast to reduced socially dynamic digital platforms, immersive virtual environments encourage higher levels of student interaction and participation. Additionally, the idea that pedagogical virtual agents developed for collaborative interaction can more effectively develop the skills and distributed cognition among learners is supported by Model 2's improved performance across conversational and role-sharing dimensions (Dalgarno & Lee, 2010). The results are in line with prvious work (Li et al., 2016; Krämer & Bente, 2010; Vogeley & Bente, 2010; Webb et al., 2017; Fitrianie et al., 2019) that focused on accessibility, pedagogical integration, human–agent interaction, collaboration, and the alignment of agent design with educational objectives. According to the contextual learning theory (Lave & Wenger, 1991), learning is most successful when it takes place in real, integrated environments.

These findings highlight the significance of digital environment diversity in determining the quality of student performance within virtual agent-supported learning environments and provide strong empirical support for the conclusion that the Virtual Agents Teams model produces significantly better learning outcomes than the Avatar model.

Conclusion

Virtual agent robot software is of great importance in many areas that can be managed over the network. This software determines repetitive behaviors and almost daily events and performs independently. It reduces the load on the teacher and allows the teacher to devote him- or herself to other things that help students learn. It does not replace teachers but rather helps them perform tasks accurately and quickly. It provides data about students' learning within the environment or the platform used. The robots can adapt and learn, and their actions and decisions change with time and according to need. The form of virtual agent robots used in learning environments must be related to the topic of learning (knowledge, skills, attitudes,and values) that is presented to students. It is also linked to the characteristics of students in terms of age group and factors (age, form, and the social and economic level) for students. The form of the virtual agent robot expresses its role in the environment used, following an educational model such as that of a teacher, a coach, or a colleague. Preferably, the robot is in the form of a character that represents a symbolic visual stimulus far from the personalities known to students to avoid distraction and cognitive overload. The tasks of virtual agent robots may vary when used within an electronic environment. They are not limited to directing educational content and guidance in chats but can be given other roles as a fellow learner to other learners, considering that the role implemented is clarified. The current research contributes to education because it is useful in providing curriculum designers with the most effective virtual agent robots in the ICT programming aspect of the course. It provides virtual agent robot developers with standards and guidelines when designing and developing these systems. It guides the attention of educational institutions to the best models for programming content and support processes for teachers in the classroom.

Ethical Approval:
All procedures performed in the study followed the ethical standards of the institutional research committee of the Deanship of Scientific Research at Mansoura and with the 1964 Helsinki declaration and its later amendments.

"**Informed consent to participate** was obtained from all the participants in the study. The ethics committee (the institutional research committee of the University of Mansoura) approved this procedure. We ensure that participants participate voluntarily and respect the confidentiality and anonymity of our research participants.

Data Availability Statement:
Data Availability Statement: We consent to the publication of data supporting the conclusion of this article, which will be available upon request to the corresponding author and may include a photograph(s), video clips, case history, and/or details within the text ("Materials") to be published in the Journal and Article.

Conflicts of Interest:
The authors declare no conflicts of interest. No other party played a role in the study's design, data collection, analysis, interpretation, manuscript writing, or decision to publish the findings, and the research was applied to students (while they were learning) and did not include animal experiments.

Author Contributions
- **Dr. Shaimaa Mahmoud Abdelwahab**: Procedure and preparation of tools, discussion, and conclusion. originator of the concept, assumptions, methods, and editing.
- **Dr Amir Shahin**: originator of the concept, research motivation, and problem
- **Dr. Maysoun Adel Mansour:** Procedure and prepare tools, discussion, and conclusion.
- **Dr. Hassan A. El-Sabagh**: Conceptualization, research tools, data analysis, Discussion, conclusion, and editing

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