ESJ Social Sciences

The Effectiveness of Using a Cognitive Style-based Chatbot in Developing Science Concepts and Critical Thinking Skills among Preparatory School Pupils

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Doi:10.19044/esj.2022.v18n22p52

Submitted: 14 June 2022
Accepted: 18 July 2022
Published: 31 July 2022

Cite As:
Barsoun S.S., Elnagar M.S., Awad B.M. (2022). *The Effectiveness of Using a Cognitive Style-based Chatbot in Developing Science Concepts and Critical Thinking Skills among Preparatory School Pupils*. European Scientific Journal, ESJ, 18 (22), 52. https://doi.org/10.19044/esj.2022.v18n22p52

Abstract

The research investigated the effectiveness of using a cognitive style-based chatbot in developing science concepts and critical thinking skills among preparatory school pupils. To achieve the aim of the research, the researchers applied the two groups' quasi-experimental design and utilized three instruments as follows;1) Budner scale to measure the tolerance of ambiguity; 2) Science concepts achievement test developed by the researchers and implemented before and after applying a cognitive style-based chatbot; 3) The critical thinking skills test developed by the researchers to identify four critical thinking skills required for grade 8 level and implemented before and after applying a cognitive style-based chatbot. The participants were chosen randomly from eighth-graders (N=50) at HOIS (Hurghada Official International School), Red Sea Governorate, Egypt. The researchers divided participants into two experimental groups of 25 pupils (EGA) and (EGB) according to their cognitive style as tolerant or intolerant of ambiguity.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Quantitative results showed the significant mean differences between the scores of participants at level (0.005 ≥) in the pre-post testing procedures in favor of the post-testing for both dependent variables (science concept and critical thinking skills). Results indicated the positive impact of utilizing a cognitive style-based chatbot in developing science concepts and critical thinking skills for preparatory school pupils. So, the researchers recommended employing chatbots in learning science for their high effectiveness in developing science concepts and critical thinking skills among preparatory school pupils in Egypt.

Keywords: Chatbot, Cognitive style, Science concepts, Critical thinking skills

1. Introduction

The world has enormously changed in the last two decades due to the technological advancements that have converted the world into a global village. Globalization has influenced several aspects of our life and education in particular. It has changed the way humans teach and learn by creating more challenges for teachers to explore effective teaching methods that suit learners' cognitive and learning styles. In this concern, designing interactive e-learning environments that consider learners' traits, characteristics, and information-processing methods, and investigating the role of student learning styles becomes crucial, especially in terms of achievement and attitudes. Tolerance and intolerance of ambiguity are characteristics that affect how an individual learns and the methods of receiving and processing information (Ismaeel, D., & Al Mulhim, E., 2019). Khalifa, A., (2011) asserted that education in general and teaching science, in particular, is concerned with the integrated growth of the learner in the cognitive, skill, and emotional aspects. Meanwhile, the main task of teaching science is to teach learners how to think, not only how to memorize (p.329). Furthermore, science is one of the core subjects that contribute to the development of individuals and nations, as it is one of the pillars that connect technology and socio-economic development (Kusi, C. (2017).

Moreover, Abuzied, A. H., & Mohamed, A. (2019) defined one of the most significant goals of learning science and other curricula is to acquire the appropriate science concepts to develop the learner's ability to use the scientific method and contribute to achieving the educational goals. Educators emphasized the significance of acquiring science concepts which became the main goal in all subjects and educational stages (p.95).

Furthermore, the integration of modern educational technologies in teaching science was one of the crucial topics occupied by educators and researchers recently to enhance the learners' science concepts and acquire the 21st-century skills to improve the learning process and its outcomes. Artificial

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Intelligence is one of the fastest-growing technologies in the education sector that has promoted changes in schools, teaching methods, learning methods, campus environment, curricula, and the entire education industry (Karsenti, T., 2019).

Thus, the spreading of the artificial intelligence concept through social networks increases the use of its techniques and digital tools that creates interactive learning environments to overcome the individual differences among learners. AI-powered chatbots have appeared across many platforms such as Facebook and Skype as digital assistants for users depending on simulation and automatic text chatting. Moreover, several studies have indicated the effectiveness of using chatbots in education, for instance, the studies by (Roos & Sofie, 2018; Bii P.K& others,2018; Fryer, L. et al, 2017; Abbasi. S & Kazi. H., 2014; Kowalski. S, et al, 2013) confirmed the positive impact of using chatbots in the education sector.

Despite the tremendous development of integrating artificial intelligence tools and applications in the educational sector, science educators keep applying the conventional teaching methods in schools and colleges, especially in developing countries. Therefore, this research seeks to investigate how teachers could utilize creative and innovative teaching methods such as employing cognitive style-based chatbots to develop science concepts and critical thinking skills among eighth-graders to keep pace with the tremendous scientific and technical revolution that Egypt is going through for achieving the sustainable development goals considering Egypt Vision (2030).

2. Problem of the Research:

Science teaching mainly aims at providing students with concepts of science and critical thinking skills as one of the most important 21st-century skills. Therefore, there is a real need to adopt new technologies that enhance and enrich the learning experience of middle-stage pupils. Studies found a proven weakness in developing science concepts and critical thinking skills among middle-school pupils. In addition, the researcher also confirmed the existence of the problem through many sources as follows:

First, due to the researcher's experience as a science HOD (Head of Department) at HOIS (Hurghada Official International School) and as a science teacher for middle and upper grades. The researcher noticed the problem through direct observation of students during science sessions, class discussions, and activities; by tracking pupils' progress and scores on science assignments, assessments, and final tests; and by conducting individual and group interviews with science teachers to follow up on their work and identify problems that hinder pupils' achievement in learning science learning.

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Second, the researcher conducted a pilot study on (30) males and females of the preparatory stage for the academic year (2020/2021) using an electronic questionnaire divided into two sections: The first section contains (10 Multiple-choice questions) about the difficulties pupils encounter while learning science and the second section is for writing the students' comments and suggestions about how to improve the development of science concepts and critical thinking skills. The researcher distributed the questionnaire through the Microsoft Team platform, and the results revealed that (70%) of the pupils were unable to develop the science concepts and apply them in real-life situations. (80%) of them cannot think critically and answer the problem-solving questions found in their science lessons, and (95%) wanted to learn in new and innovative technological ways.

Third, relevant literature and previous studies were reviewed in this context and revealed deficiency in the development of science concepts and critical thinking skills such as the studies by (Khalil, E. 2020; Elmasry, H., 2020; Elkebeby, A., 2019; Al–Harahsheh, K., 2019; Elkebeby, A., 2019; Elajmi, S., 2018; Susiani, T., Salimi, M., & Hidayah, R., 2018 Abowazna, F., & Abogaber, M., (2017). Moreover, other studies have also revealed that learning techniques embedded in curricula could foster in-depth learning and help students understand science concepts and processes; hypermedia technology is one of these (Yang, D., & Baldwin, S., 2020).

Fourth, taking into account (TIMSS, 2019), the seventh assessment cycle was conducted in 64 participating countries worldwide. Egypt ranked **62** from 64 countries participating in the science achievement test, indicating a low level of achievement of common core standards for science subjects for middle-school pupils (grade-8). Hence, the main recommendations of many recent conferences held in Egypt such (Developing Education in Egypt-Challenges and prospects of success, 2019); (Egypt can by science, 2018); and (The education in Egypt towards creative solutions, 2017) proved that there is a need to develop curricula, teaching methods integrating technology and develop the primary education system (teachers, schools, and curriculum) to show an out-of-the-box vision during the artificial intelligence era.

Based on the above, the researcher suggested using a cognitive style-based chatbot to emphasize its effectiveness in enhancing the pupils' learning experiences inside and outside the classroom by developing science concepts and critical thinking skills. Therefore, the research problem is represented in the lack of development of science concepts and critical thinking skills among preparatory school pupils.

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3. Questions of the Research:

The problem of the research tackled the following main question:

"What is the effectiveness of using a cognitive style-based chatbot in developing science concepts and critical thinking skills among preparatory school pupils?"

The main question is branched into five subsequent questions as follows:

3.1. What are the science concepts required for preparatory school pupils?

3.2. What are the critical thinking skills needed for preparatory school pupils?

3.3. What is the proposed educational design of a cognitive style-based chatbot?

3.4. What is the effectiveness of using a cognitive style-based chatbot in developing science concepts among preparatory school pupils?

3.5. What is the effectiveness of using a cognitive style-based chatbot in developing critical thinking skills among preparatory school pupils?

4. Objectives of the Research:

The research aims to achieve the following objectives:

4.1. Developing science concepts and critical thinking skills of preparatory school pupils.

4.2. Formulating an instructional design of cognitive style (tolerant/intolerant of ambiguity)-based chatbot to develop science concepts and critical thinking skills among preparatory school students.

4.3. Identifying the effectiveness of using a cognitive style (tolerant/intolerant of ambiguity)-based chatbot in developing science concepts among preparatory school students.

4.4. Identifying the effectiveness of using a cognitive style (tolerant/intolerant of ambiguity)-based chatbot in developing critical thinking skills among preparatory school students.

5. Significance of the Research:

This research is believed to be significant for the reasons described below:

5.1. Directing the attention of those in charge of the educational process to develop innovative educational applications convenient for the different cognitive styles of students by making use of artificial intelligence technology and employing its tools in the educational process.

5.2. Developing science concepts and critical thinking skills among middle-school pupils to improve their academic achievement and performance.

5.3. Detecting new ways of learning based on a student-centered approach and providing customized learning methods to overcome individual differences among students.

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5.4. Providing a new framework based on integrating artificial intelligence technology into teaching science and other subjects.
5.5. Guiding the curriculum developers to design chatbots based on different cognitive styles and integrating them into the science curricula as enrichment materials.
5.6. Providing instructional instruments and learning materials that can be used by other eighth-grade science teachers.

6. Research Variables:

The research relied on the following variables:

6.1. Independent Variable:

A cognitive style-based chatbot

6.2. Dependent Variables:

a. Science concepts
b. Critical thinking skills

7. Hypotheses of the Research

The research relied on the following hypotheses:

H.1. There would be a statistically significant difference at the level (0.05) between mean scores of the science concept achievement test in pre and post-test in favor of the post-test.
H.2. There would be no statistically significant difference at the level (0.05) between the first experimental group (ambiguity tolerant) EGA and the second experimental group (ambiguity intolerant) EGB in the post-application of science concept achievement test.
H.3. There would be a statistically significant difference at the level (0.05) between mean scores of the critical thinking skills test in pre and post-test in favor of the post-test.
H.4. There would be no statistically significant difference at the level (0.05) between the first experimental group (ambiguity tolerant) EGA and the second experimental group (ambiguity intolerant) EGB in the post-application of critical thinking skills test.
H.5. There would be an effectiveness of using a cognitive style-based chatbot in developing science concepts among preparatory school pupils.
H.6. There would be an effectiveness of using a cognitive style-based chatbot in developing critical thinking skills among preparatory school pupils.

8. Method

8.1. Participants of the Research:

The researchers randomly selected the participants from the eighth-grade pupils at HOIS (Hurghada Official International School), Red Sea Governorate, Egypt and divided (50) Participants into two experimental

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groups EGA, and EGB according to their cognitive style as tolerant and intolerant of ambiguity based on their score on the Budner scale. The content covered was unit four (Humans and their places in the universe) of the eighth-grade science curriculum.

The researchers used pre-posttest procedures and compared and analyzed the participants mean scores using SPSS (Version 21) software to investigate the difference in mean scores for both experimental groups before and after applying the cognitive style-based chatbot. The cognitive style-based chatbot was built using the ADDIE Instructional Design Model and integrated into the Science Team channel within the Microsoft Team platform.

Table 1. The Distribution of the Research Sample

Group	Students (N)	Total Percentage
Experimental Group (EGA)	**25**	**50%**
Experimental Group (EGB)	**25**	**50%**
Total	**50**	**100%**

8.2. Research Design:

Descriptive approach was used in the current research to analyze literature related to the research variables, describe and build research tools, and discuss and interpret the results. The research followed the two-groups quasi-experimental design with its pre-post testing procedures. The researchers divided the participants into two experimental groups (EGA) and (EGB) as tolerant and intolerant of ambiguity based on their scores on the Budner scale. The researchers designed the cognitive style-based chatbot using the ADDIE Instructional Design Model and integrated it into the Science Team channel within the Microsoft Team platform as it is the official learning management system (LMS) used by the school administration to create the blended learning environment.

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Table 2. Quasi-experimental design of the Research

Taxonomic Measurement	**Groups**	**Pretests**	**Treatment**	**Post-tests**
Budner Scale (Tolerance of ambiguity test)	Experimental Group (EGA) (Tolerant of ambiguity)	Science concepts achievement test Critical thinking skills test	A cognitive style-based chatbot	1. Science concepts achievement test 2. Critical thinking skills test
	Experimental Group (EGB) (Intolerant of ambiguity)			

8.3. Instrumentation:

The following instruments were designed and utilized by the researchers:

8.3.1. Data Collection Instrument:

The researchers prepared an online questionnaire consisting of two sections: The first section included (10 MCQ questions) to reveal the difficulties that pupils face in learning science, and the second section was open to write the pupils' comments and suggestions on how to develop science concepts and critical thinking skills. The researchers used Microsoft Forms to write the questionnaire and the Microsoft Team platform to send it.

8.3.2. Measuring Instruments:

1. Budner scale to measure the cognitive style (Tolerance/intolerance of ambiguity). The test was validated for its validity and reliability. The validity of the test was run through content validity (Jury validation) and Cronbach's Alpha statistic was applied. The value of (r) was (0.839), which indicates a high-reliability coefficient.
2. Science concepts achievement test to measure the development of science concepts related to the fourth unit (Humans and their places in the universe) of the eighth-grade science courses. The test was validated for its validity and reliability. The validity of the test was run by content validity (Jury validation) and Cronbach's Alpha statistic was used. The value of (r) was (0.961), which indicates a high-reliability coefficient.
3. Critical thinking skills test to measure four of the main critical thinking skills (evaluation of arguments, recognizing assumptions, deductions,

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and inferences) included in unit four (Humans and their places in the universe) of eighth-grade science courses. The test was validated in terms of validity and reliability. The validity of the test was run by content validity (Jury validation) and Cronbach's Alpha statistic was used. The value of (r) was (0.955), which indicates a high-reliability coefficient.

8.3.3. Treatment Instrument

A chatbot based on the cognitive style (tolerance/ intolerance of ambiguity) was built using a power virtual agent app and integrated into the eighth-grade Science Team channel. Pupils could use it through their chat tap in their Microsoft Team platform or as a custom application within the Microsoft Team applications tap.

8.4. Delimitation of the Research:

- **Thematic Limitation**: Using the cognitive style-based chatbot in teaching the fourth science unit (Humans and their places in the universe) to eighth-graders.
- **Spatial Limitation:** Hurghada Official International School (HOIS), Red Sea Governorate, Egypt.
- **Time Limitation:** The research was conducted during the 4th quarter duration. (From May 1, 2022 to June 15, 2022).
- **Human Limitation:** The research sample was randomly selected from the eighth-grade pupils at HOIS School.

8.5. Data Analysis:

Statistical analysis of the collected data was applied using the Statistical Package for Social Sciences (SPSS) Version (21) to process and calculate the data by applying the following statistical styles:

1. A paired-Samples t-test to compare the mean scores for the pre- and post-applications of both critical thinking skills test and science concepts achievement test.
2. Effect size to study the effect of the independent variable (a cognitive style-based chatbot) on the dependent variables (science concepts and critical thinking skills) to find out the variation in the degrees of the dependent variables that are attributed to the effect of the independent variable. Therefore, the effect factor was extracted using Eta2 via (t) value resulting from the mean difference in critical thinking skills and science concepts achievement tests for preparatory school pupils in pre and post-tests.

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3. Using the two independent samples t-test to compare the mean scores of the first experimental group (EGA) and the second experimental group (EGB).

9. Theoretical Framework:

Artificial intelligence is one of the recent trends that influenced modern education and transformed the ways of teaching and learning methods of digital learners who have grown up in a fast-paced technological world. Therefore, the researchers confirmed that technology has successfully penetrated education systems across the world and quickly transformed the education sector making learning more accessible, attractive, and efficient.

With the help of Artificial Intelligence (AI) and its tools, teaching and learning had brought about drastic changes in the education sector. The chatbot is one of the Artificial Intelligence tools that have been used in the educational sector and has a long history as one of the essential tools of the educational process since the 1970s because it was developed within the digital learning and training environments known as Intelligent Tutoring Systems (ITS).

Moreover, Bii, P., & Too, J. (2016) defined a chatbot as computer software that simulates an intelligent human interaction language through text or speech to conduct a conversation or imitate informal chat communications between a human user and a computer using natural language, while the study by (Oudeyer, P. Y., Gottlieb, J., & Lopes, M., 2016) pointed out that chatbots are used to create curiosity by asking students challenging questions, which is the main driver of intrinsic motivation. Furthermore, Khan, R., & Anik, D. (2018) ensured that the chatbot helps respond to all human requests and is available 24 hours a day. However, the most significant advantage of chatbots is the ability to serve a large group of audiences at the same time and automate custom messages.

Furthermore, the studies by (Chen, H., VickiWidarso, G., & Sutrisno, H., 2020; Fakash, Z., 2018; and Radziwill, N., & Benton, M., 2017) have confirmed the advantages of using chatbots in education by freeing up time to work with students and making sure they understand the content. Chatbots are very interesting and entertaining educational tools that turn the course to a thread as an ongoing conversation between a teacher and his students and between a student and his classmates. Chatbots also help students learn at their own pace due to their ability to provide an individualized learning.

Therefore, the researchers suggested incorporating a chatbot based on the pupils' cognitive style as tolerant or intolerant of ambiguity to deal with the individual differences in several cognitive variables and to express preferred ways of interacting with information within the learning environment.

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Budner (1962) defined ambiguity tolerance as "the tendency of students to perceive ambiguous situations as necessary". In contrast, intolerance of ambiguity has been described as "the tendency to perceive ambiguous situations as sources of threats." (p.29)

In addition, a summary of findings across studies indicated the significance of tolerance of ambiguity as a required feature of creativity, such as (Decay, J., 1989). Who confirmed that mystery is an essential trait of creativity.

Thus, the researchers summarized the differences between pupils who are tolerant and intolerant of ambiguity as follows: Tolerant of ambiguity is more flexible and open-minded than intolerant of ambiguity; They are more responsible than intolerant of ambiguity; They accept ambiguous situations and ideas while intolerant of ambiguity do not accept any new or unfamiliar situations; They have critical thinking skills while intolerant cannot think critically; They are highly motivated to seek knowledge and receive unfamiliar situations as reinforcer while intolerant of ambiguity are less motivated and perceive unfamiliar situations as threats; and they tend to choose irregular paths in their learning while intolerant of ambiguity prefer the regular paths in their learning.

From the above, the researchers emphasized the significance of the cognitive style in learning science concepts in particular, as it's the basis for building scientific knowledge and one of the most significant learning outcomes through which scientific knowledge can be acquired and given meaning. Moreover, teaching science concepts is one of the recent trends in science teaching as it helps in achieving the objectives of the scientific course. In the same context, (Mostafa, M., 2014) confirmed that "learning scientific concepts is a basic goal of school learning, and it plays an important role in highlighting the importance of scientific material for the learner, which has the greatest impact on increasing the motivation and the active participation of learners in the learning process." (p.102). Despite the crucial role of science concepts development, many studies have demonstrated the inadequacy of science concepts development such as (Gaber, G., & Hassan, A., 2001, p. 53 and Duit et al., 2001, p.295) that pointed out some of these difficulties due to two types of factors as follows:

First, the external factors are the use of inappropriate curricula and teaching strategies, the level of preparation of the science teacher, and the use of non-scientific language.

Second, the internal factors appeared as the lack of desire, motivation, tendency to learn, lack of intelligence, and the ability to discriminate and perceive information.

Furthermore, the researchers have argued that learning and developing science concepts for middle-school pupils, especially in HOIS school, is a

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difficult and overwhelming task because of the pupils' different learning experiences, scientific backgrounds, and cognitive and learning styles.

Therefore, the researchers recommended the use of a cognitive style-based chatbot to help pupils to understand, develop, and apply science concepts included in their science course as well as develop the critical thinking skills required for preparatory school pupils as one of the most essential of 21^{s} century skills and considered as educational goals that must be achieved through science teaching. Science is one of the core subjects that improve critical thinking in problem solving and decision-making at the middle-school level.

A study by (Susiani, T., Salimi, M., & Hidayah, R., 2018) defined critical thinking as "the ability to think rationally, reflexively, analytically, and efficiently in judging any situation to make the appropriate decision." (p. 2). Critical thinking also includes a set of overlapping cognitive strategies and processes such as interpretation, analysis, evaluation, and conclusion with the view of performance, beliefs, evidence, proofs, concepts, and claims that are relied upon when making a judgment, solving a problem, or decision-making, taking into account the opinions of others (Khalifa, A., 2011).

There is an urgent need for critical thinking, especially with the progress, development, complexity, and high levels of life, which affected many psychological and cognitive variables among students. Moreover, global changes and technological progress directly affect education. Therefore, using these high-level thinking skills enables students to examine information and make logical decisions because of its several benefits such as preparing students for college, future careers, and life success (Stobaugh, R., 2013).

10. Findings and Discussions:

The researchers utilized two instruments (Science concepts and critical thinking skills tests) to test the researchers' hypotheses. The following results were obtained and analyzed using SPSS statistical software version (21) as follows:

H.1. There would be a statistically significant difference at the level (0.05) between the mean scores of the science concepts achievement test in pre and post-test in favor of the post-test. To validate the first research hypothesis, a paired Sample t-test was used as shown in the following table.

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Table 3. Paired Sample Statistics of Science Concepts Achievement Test

Application	Mean	Std. Deviation	**Earning**		(t) Value	df	Sig.	Eta^2
			Mean	Std. Deviation				
Pre	24.18	1.837	33.920	2.784	86.165	49	0.000	0.993
Post	58.10	1.619						

The above table indicates that the post-test scores are higher than the pretest scores. Therefore, there is a development in the pupils' science concepts after the implementation of the cognitive style-based chatbot.

H.2. There would be no statistically significant difference at the level (0.05) between the first experimental group (ambiguity tolerant) and the second experimental group (ambiguity intolerant) in the post-application of the science concepts achievement test. To validate the Second research hypothesis, the independent sample t-test was used as shown in the following table.

Table 4. Independent Sample T-Test of Science Concepts Achievement Test

Application	Mean	Std. Deviation	Earning		(t) value	Sig	df
			Mean	Std. Deviation			
Experimental (1) Tolerant of ambiguity (EGA)	58.32	1.600	0.44	2.123	0.960	0.342	48
Experimental (2) Intolerant of ambiguity (EGB)	57.88	1.641					

The table shows the t-test value between the mean scores (0.960), which has no significance at the level (0.05). Since the calculated significance is equal to (0.342) and more than (0.05), this means that the null hypothesis and the second research hypothesis are accepted.

H.3. There would be a statistically significant difference at the level (0.05) between the mean scores of the critical thinking skills test in pre and post-test in favor of the post-test. To validate the third research hypothesis, a paired sample t-test was used as shown in the following table:

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Table 5.Paired Sample T-Test of Critical Thinking Skills Test

Application	Mean	Std. Deviation	**Earning**		(t)	df	Sig.	Eta^2
			Mean	Std. Deviation				
Pre	20.60	1.512	27.060	1.570	121.854	49	0.000	0.997
Post	47.66	0.982						

Table No. (5) shows the value of the t-test between the mean scores (121.854), which is significant at the level (0.05). Since the calculated significance is equal to (0.000) and is less than (0.05), this means rejecting the null hypothesis and accepting the third research hypothesis. In addition, the value of Eta^2 was (0.997) which indicates the positive effect of using chatbots in developing critical thinking skills for preparatory school pupils.

H.4. There would be no statistically significant differences at the level (0.05) between the first experimental group (ambiguity tolerant) and the second experimental group (ambiguity intolerant) in the post-application of the critical thinking skills test. To validate the fourth research hypothesis, an independent sample t-test was used as shown in the following table.

Table 6. An Independent Sample T-Test of Critical Thinking Skills Test

Application	Mean	Std. Deviation	Earning		(t)	Sig	df
			Mean	Std. Deviation			
Experimental (EGA) Tolerant of ambiguity	47.84	0.898	0.36	2.543	1.306	0.198	48
Experimental (EGB) Intolerant of ambiguity	47.48	1.046					

Table No. (6) shows the value of the t-test between the mean scores (1.306), which has no significance at the level (0.05). Since the calculated significance is equal to (0.198) which is more than (0.05), this means that the null hypothesis and the fourth research hypothesis are accepted. From the above results, it is worth noting that the use of a cognitive style-based chatbot had a positive effect on the development of critical thinking skills for both groups regardless of their cognitive style as tolerant or intolerant of ambiguity.

H.5. There would be an effectiveness of using a cognitive style-based chatbot in developing science concepts among preparatory school pupils. To validate

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the fifth research hypothesis, the black-adjusted gain ratio for mean scores of the science concepts achievement test was calculated as shown in the table below:

Table 7. Value of the Black-Adjusted Gain Ratio Between Pre- and Post-Application of Science Concepts Achievement Test

Mean Scores of Pre-test	Mean Scores of Post-test	Total Grade	Black Adjusted Gain Ratio	Significance
24.18	**58.10**	**70**	**1.916**	**Accepted**

Table NO. (7) above shows that the value of the black-adjusted gain ratio between pre- and post-application of the science concepts achievement test reached (1.916), which is higher than (1.2). This indicates the high effectiveness of using the cognitive style-based chatbot in developing science concepts among preparatory school pupils.

H.6. There would be the effectiveness of using a cognitive style-based chatbot in developing critical thinking skills among preparatory school pupils. To validate the sixth research hypothesis, the black-adjusted gain ratio for the mean scores of pre- and post-application of critical thinking skills test was calculated to determine the effectiveness of using a cognitive style-based chatbot in developing critical thinking skills among preparatory school pupils as shown in the following table.

Table 8. Value of the Black-Adjusted Gain Ratio Between Pre and Post-application of Critical Thinking Skills Test

Mean Scores of Pre-test	Mean Scores of Post-test	Total Grade	Black Adjusted Gain Ratio	Significance
20.60	**47.66**	**52**	**2.174**	**Accepted**

The above table shows that the value of the black-adjusted gain ratio between pre- and post-application of the critical thinking skills test reached (2.174), which is higher than (1.2). This indicates high effectiveness of using the cognitive style-based chatbot in developing critical thinking skills among preparatory school pupils.

Discussion

The research examined the independent variable (a cognitive style-based chatbot) to identify its effect on dependent variables (science concepts and critical thinking skills). The results obtained from the experiment revealed high effectiveness of using the cognitive style-based chatbot in developing science concepts and critical thinking skills. The current research led to the following findings:

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- The proposed cognitive style-based chatbot has proven its effectiveness in developing science concepts and critical thinking skills for eighth-grade pupils at HOIS school.
- The feedback from the participants was positive through their comments and participation as they felt comfortable and motivated to interact with the chatbot in a supportive atmosphere so that they could develop their science concepts and critical thinking skills that were aroused from unit four (Humans and their place in the universe) for the eighth grade.

These findings agree with several studies such as (Yin, J., Goh, T., Yang, B., & Xiaobin, Y., 2020; Sumutny, P., & Schreiberova, P., 2020; Sandu, N., & Gide, E., 2019; and Winkler, R., & Söllner, M., 2018) which confirmed the positive impact of using chatbots to enhance teaching and learning processes in the education sector.

On the other hand, the current research differs from other studies because it is based on creating a chatbot based on the pupils' cognitive style as tolerant or intolerant of ambiguity and it is applied in the fourth learning unit (Humans and their place in the universe) from the eighth-grade science curriculum. Accordingly, the proposed chatbot provided accurate answers to all FAQ questions related to the eighth-grade science course. Pupils were encouraged to participate and engage in their own learning process so that they could develop their science concepts as well as their critical thinking skills.

Conclusion

Based on the research findings, implementing a cognitive style-based chatbot in learning science courses can lead to the development of the science concepts as well as critical thinking skills of preparatory school pupils because the chatbot provided an opportunity for the pupils to be engaged and immersed in their own learning process and provided more practice to retain knowledge. In conclusion, the use of chatbots in learning science has improved pupils' achievement and performance. Based on the above results and relevant literature, the researchers confirmed the effectiveness of using a cognitive style-based chatbot in developing science concepts and critical thinking skills among preparatory school pupils as follows:

A. Chatbots can be used to increase curiosity by asking pupils challenging questions, which is one way to develop critical thinking skills.
B. Chatbots can help pupils organize their own learning process by working at their own pace.
C. Chatbots can be a knowledge resource that supports learning in the classroom by changing the educational environment to one that is student-centered and this has been confirmed by constructivist theory.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

D. Chatbots Provide an effective means of collaboration and communication with pupils through conversations and chatting. They provide them with accurate scientific information and answers to questions that hinder their understanding according to communication theory.
E. Chatbots provide immediate feedback and individually lead pupils in their own learning process, in line with learning style theory.
F. Chatbots increase the pupils' motivation to learn and enhance their self-awareness in line with a motivation theory.
G. Chatbots make pupils more engaged and immersed in their learning process inside and outside the classroom.
H. Chatbots address individual differences of pupils by providing personalized learning.

Moreover, the Implications of the research can be beneficial to various stakeholders as follows:

1. Curriculum designers and developers can integrate chatbots as a supportive educational tool in Egyptian educational institutions as part of their educational processes in learning science and other subjects to overcome individual differences among preparatory school pupils and positively influence pupils' achievement and performances; Holding workshops to train teachers on the use of technological tools and artificial intelligence tools in particular; Shedding light on the development of critical thinking skills as one of the most important skills of 21st century, especially in teaching science curricula.
2. Science teachers are advised to consider the use of chatbots to support their teaching process and enhance the learning of their pupils; incorporating different technological tools into their teaching methodology, and selecting effective methods for interacting with their pupils and their science content.
3. Learners: Participants of the experiment showed their satisfaction with using the chatbot in learning science as described in the chatbot analytics and the feedback of eighth-graders. Thus, the implementation of chatbots in learning different topics can improve the pupils' learning experience.
4. Theory: The proposed framework can be added to the literature on designing science courses. Therefore, it can be used as a basis for further studies in the field of curricula and methodology. The results of the research highlighted several recommendations, including
5. Providing science teachers with professional development in terms of using technology and integrating artificial intelligence tools in teaching methodology.

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6. Integrating chatbots based on learners' different cognitive styles to enhance their learning process.
7. Integrating various technological tools to develop critical thinking skills as one of the most important 21st-century skills required for the digital natives.
8. Integrating chatbots into different educational systems in national learning as well as international curricula.

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