The Effectiveness of E-Collaborative Learning in Developing Digital Thinking Skills among Teachers in the Light of Connectivism Theory

Osamah Mohammad Ameen Aldalalah*, Ali Sami Ali Alhalaq, and Yousef Ahmed Eyadat

***Abstract*—The current study aimed to find out the effectiveness of Electronic Collaborative Learning (ECL) in developing digital thinking skills among teachers in the light of connectivism theory. The researchers used the quantitative method (quasi-experimental). The actual number of the study sample consisted of 32 teachers from the digital skills diploma teachers for the primary stage at Taibah University who were registered in the Advanced Digital Applications course (CS552) in the second semester of the academic year 2021–2022. They were distributed randomly into two groups. The researchers used three instruments in the study, the first instrument: testing the concepts of digital thinking skills, the second instrument: observation for digital thinking practices, and the third instrument: a questionnaire was adapted of teachers' attitudes to digital thinking. This is done by analyzing the sample responses of the parameters on the three study instruments (testing the concepts of digital thinking, the digital thinking skills observation card, and its questionnaire about attitude towards digital thinking). The results showed that there was an effectiveness of electronic collaborative learning in developing digital thinking skills for teachers in the light of communication theory. Based on the results, the researchers recommended activating electronic collaborative learning based on connectivism theory to develop digital thinking skills.**

***Index Terms*—E-collaborative learning, digital thinking, connectivism theory, digital skills, diploma, teachers**

I. Introduction

Education witnessed a quantum leap in the twenty-first century, because the wide spread of educational methods that depend on technological innovations, so the movement towards knowledge, building it, sharing it, and managing it became a in quantity and quality of interest of knowledge and educational communities, which necessitates changing the concepts and methods of traditional teaching and learning, to meet the needs of students, by providing educational content that is easy to access, the learner plays the main role in building it, by finding channels of communication and sharing with others, and exchanging opinions, experiences, knowledge, and skills, all of this requires educational tools that help expand and spread in all fields of knowledge.

The digital and technological tools that facilitate this type of learning, which are on a constructive and collaborative basis, provide sufficient opportunity for learners to interact with their colleagues and teachers, this allows them to exchange their ideas and learn about their feelings, and this is known as electronic collaborative learning.

Electronic collaborative learning aims to provide creative learning strategies and environments, including all learning and teaching experiences, which are provided through synchronous and asynchronous digital technology. This is done through the formation of special virtual communities that constitute spaces for interaction and discussion, in which teachers and students participate in conversations and exchange knowledge and ideas. They are effective in students' learning, because they propose ideas by exchanging opinions, so they have a new understanding stemming from a multiplicity of opinions and suggestions [1].

In light of the widespread spread of e-learning systems, educational environments have become in need of learning theories that are in line with the digital age, which considers education as networks and sources of learning and the acquisition of knowledge and skills, by involving students in learning and building their knowledge stock, and increasing interaction and communication of students with each other and with teachers from Through digital communication channels that facilitate the learning process, one of the most important of these theories is connectivism theory [2].

The connectivism theory came to explain technology-based networked learning and how it occurs in the renewed social environments of the digital age, which is based on interconnected and huge knowledge that requires multiple learning networks to produce knowledge and achieve learning. This requires the development of competencies, abilities, and personal skills among students, the most important of which are skills. Different thinking, which are mental activities used to process information, make connections, make decisions, and create new ideas [3].

One of the most important thinking skills in the current (technological) age is digital thinking skills, which is considered one of the basic thinking skills in the twenty-first century, which depends on solving problems, analyzing, and designing systems, and discovering and understanding human behavior based on digital concepts. These skills must be possessed by all students, as they are an essential part of the educational curriculum [4].

Digital thinking in its contemporary sense is among the latest modern trends in the development of thinking skills. Although the concept of digital and computational thinking has received a great deal of attention over the past several years, some studies have shown that digital thinking skills are

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not taught effectively in education. General or university education [5], in addition to the lack of studies that dealt with the subject of digital thinking skills, in electronic and digital education courses, even though digital thinking has become one of the main skills for living in the twenty-first century because it is closely related to various areas of life, especially digital ones. and due to the great interdependence between the different digital applications and digital thinking, which may be reflected in the perceptions of the learners, they will be able to apply the skills of digital thinking within any digital environment, away from the restrictions that may contain.

Therefore, based on the above and according to the researchers experience in field work and reviewing many previous studies [2, 6–9] it was found that there was a weakness in the skills of digital thinking among teachers of the Diploma in Digital Skills for the primary stage, which prompted the researchers to design an educational program and apply it in order to develop digital thinking skills in general, within a modern learning environment there is a need and characteristics of learners at this stage. This study came to reveal the effectiveness of collaborative e-learning in developing digital thinking skills. Although studies [10–13] confirm the effectiveness of using electronic collaborative learning due to its many advantages, the vast majority of learners do not benefit from the services electronic collaborative learning is largely because it may not meet their needs in a way that suits their learning styles, this due to the fact that electronic collaborative learning environments do not help learners to interact and integrate easily in their preparations, interests and learning style, and to improve digital thinking skills according to electronic collaborative learning requires the adoption of a learning theory that fits with the nature and characteristics of digital skills diploma teachers for the primary stage and their learning styles, such as connectivism theory, which is considered one of the best educational theories in the digital age, as revealed by many studies [2, 14–16] which focuses on the use of digital technology in learning based on networks within an effective social framework.

This study aimed to identify the effectiveness of electronic collaborative learning on the development of digital thinking skills among teachers (Diploma in digital skills for the primary stage), in the light of the connectivism theory that emanates from it (concepts of digital thinking, practices of digital thinking, trends of digital thinking). In addition, the study aimed compare collaborative learning with learning through virtual classrooms.

II. Literature Review

A. E-Collaborative Learning

The twenty-first century witnessed a heavy presence of information and communication technology, which completely changed learning styles and the role of both teachers and students, in addition to changing the methods of acquiring the necessary knowledge and skills in education, the most important of which is working together in a team to achieve certain goals, Collaborative-based learning has now become an essential element in the learning method. It helps to actively participate in learning, produce innovations that encourage research, access to information, and evaluate it through a variety of sources such as peers, teachers, and society, and thus the responsibility for success becomes an individual and collective responsibility [10].

Ali [17] believes that collaborative learning recognizes the impact of technology on society and ways of accessing knowledge. Learning in the digital age does not depend on the acquisition of individual knowledge, but rather depends on connected learning that occurs through interaction with various knowledge sources (including the Internet, information containers, and learning management systems). where learning consists of self-retrieval of information, communication with others, and technical sources of knowledge creation, and the application of information in different situations. Effective students are those who can deal with problems, contradictions, and abundant information through their research in various sources. They also can learn and exchange important information and build shared knowledge. Building knowledge requires all students to develop their higher-order thinking skills and reach richer knowledge through participation and joint exploration, relying on participatory communication channels [18]. This type of learning also provides a learning environment that depends on many options, such as the freedom to choose the time, place, and method for learning that students prefer. It is more than just a communication technology, but rather a network of social relationships that depends on the student and the groups participating in the educational process through data collection, analysis, and discussion. And interpreting it, sharing information, and building knowledge by relying on collaborative tools and various electronic brainstorming tools that help in developing their thinking skills. It also provides group feedback activities, and this is known as electronic collaborative learning [11].

E-collaborative learning is defined as the learning resulting from the development of web generations, especially the development of the second generation of the web called the social web, due to which interactive and social collaborative activities emerged between students, teachers, and various learning sources, and this can only be done through electronic environment tools that help learning and sharing information. and experience to successfully complete the required tasks [12].

Mahmoud [13] defines it is an educational method based on building an effective environment that allows students to collaborate and participate in building their learning, which provides them with an opportunity to discuss, dialogue, present ideas, and express opinions, through various electronic media. Participatory learning skills depend on designing education, realizing self-worth, time management, and work. Participatory, interactive, fun learning, in addition to employing digital technologies and electronic communication. However, e-collaborative learning is one of the student-centered learning programs, through them playing an active role in the educational situation, especially in topics that aim to form personal skills for them that cannot be accessed individually, but rather need to be learned in groups, which increases the student's ability to see the situation from the points of view of others [19].

The procedures for activating e-collaborative learning depend on an educational design model suitable for the participatory learning environment considering the theories of learning and teaching, by defining its objectives, and dividing the activities into sub-tasks that the teacher distributes to the group members, so that these activities support and develop thinking skills, and work with friends within One team. The teacher must also determine the final date for delivery and explain the laws and regulations for implementing these activities in an open and clear manner, considering the difference in learners' needs, prior information, and readiness to learn, and apply the necessary standards for evaluation and build measurement tools for using modern e-learning tools. It must also be emphasized It is necessary to identify auxiliary electronic programs and applications and constantly monitor their interaction [20]. In addition to storing educational content in a digital form that allows synchronous and asynchronous interaction, and is available at any time, this type of education develops in the learner individual and collective responsibility and develops a spirit of cooperation and teamwork between him and his peers, which helps them exchange ideas and the ability to solve problems and decision making. [21]. Based on the previously mentioned results of some studies, there are other studies [22–24] that emphasize the active and positive role of employing electronic collaborative learning in many subjects and academic skills and for different educational stages. Finally, the electronic collaborative learning environment is one of the educational environments in which various technical tools and capabilities can be used to develop skills, if it is built appropriately to serve the collaborative learning environment, and in a way that makes the student a key partner in learning.

B. Digital Thinking

Developing students' mental abilities and skills is one of the areas that should be paid attention to. So that it is in line with the digital transformation and the knowledge, information, and communications revolution, which requires intellectual and social transformations in educational institutions to prepare thinking and creative students [8]. Digital technology has transformed the approach to traditional learning into using the necessary skills in a digital environment that enables students to possess digital competence as it is one of the basic skills for learning, which includes information, management, collaboration, communication, content sharing, knowledge creation, responsibility, evaluation and solving problems and technical processes. The challenges facing education require teachers and students who are more competent in intelligence, skills, use and control of digital technology, in addition to changes in teaching methods and strategies and the development of ideas. Digital thinking skills are among the most important skills for the twenty-first century, as they focus on skills in a specific situation to solve problems using computers, communications, and digital environments. [25].

Digital thinking is considered a type of thinking that focuses on information, the extent of its need, what is available of it, how to acquire it, interpret it, analyse it, store it, use it, and access it, in addition to the ability to create new knowledge using various digital tools [9]. Digital thinking can be motivating for students and enhance their creativity, as they are not consumers of knowledge, but rather producers of it, as it is most important for survival and adaptation in the surrounding environment in the current era. Therefore, creativity is currently viewed as relying on digital technology, and how it interacts with humans, and its ability to solve problems and challenges facing students [4]. Digital thinking is a higher way of thinking in dealing with life's problems. It depends on organized steps that a human or computer can follow to understand and analyze the problem and formulate the solution in a way that humans and computers can understand and apply with great skill and efficiency [6].

The American Computer Science Teachers Association (CSTA), in cooperation with the International Society for Technology in Education (ISTE), defined it as a process of solving and formulating problems through algorithmic thinking, relying on digital technical tools, logical organization of data, analysis, and representation by following modeling and simulation to arrive at the most efficient and effective possible solutions, then circulate it to benefit from it in different situations and other problems [7]. Digital thinking is considered a skill that every person must master, to be able to coexist in contemporary society, as it is the way in which humans think and not the way in which computers and digital technical tools think. It is not characterized by the skill and imagination that humans possess, but it is a means of enhancing their abilities to solve problems. the problems better [26].

Digital thinking skills are useful for students and for anyone, regardless of their scientific and practical competencies. These skills are as indicated study [4, 7, 9, 25]. (1) Algorithmic thinking: which is a series of steps that must be followed in a specific order to solve a problem (2) Analysis: By dividing the problem into small parts and being able to connect these parts. (3) Abstraction: is reducing the complexity of the problem, by focusing on what is important, and dispensing with details that may be considered redundant, which affect the solution of the problem. (4) Evaluation: which is ensuring the efficiency of the proposed algorithmic solution to the problem. (5) Generalization: which includes benefiting from the processes used in solving the problem. A specific problem and its application to other problems. (6) Simulation: It is a presentation of algorithms, which includes computer models and designs.

Based on the results of the previous studies, digital thinking focuses on understanding the problems facing teachers and students and the possibility of solving them in a digital, computerized way, with the ability to identify the most appropriate digital tools for the solution and employ them in new situations and problems.

C. Connectivism Theory

In light of the spread of e-learning systems, educational environments have become in need of learning theories that suit the digital age, which considers education as networks and sources of learning, and the acquisition of knowledge and skills, aiming to involve students in learning, in addition to building their knowledge stock, and increasing interaction and communication between them and teachers, through digital channels that facilitate the learning process, so modern learning theories have emerged that combine personal and

environmental experiences and influences. Which helps to acquire, enrich, and modify knowledge, skills, values, attitudes, behavior, and world views [15]. Hence the idea of connectivism theory proposed by Siemens in 2004, and he defined it as a theory that aims to know how learning occurs in electronic environments and social relationships. Therefore, communication theory is one of the theories associated with contemporary technological development and seeks to place learning via networks within an effective social framework.

The connectivism theory is one of the latest theories that respond to the needs of learning in the twenty-first century, using digital technology that allows students to communicate and interact and create an educational environment that makes them participants and interactors and not just recipients of information [16]. This theory is also considered an alternative to conventional educational theories such as (cognitive, behavioral, and constructivist), which depends on organized formal education without learning in informal environments (social digital transformation), such as social networks, educational games, digital environments, cloud computing, etc., connectivism theory assumes that the current stage is (the knowledge stage), which students need throughout their lives, and in which they play an active role in producing knowledge even outside the formal education process [2].

The connectivism theory is also considered an effective way to understand learning, as it activates knowledge through the process of communication and exchange of information, and entering environments with similar fields and interests that allow interaction, participation, dialogue and thinking together. The learning community is part of an information network through which knowledge is distributed and stored in the form of digital media, learning and knowledge are constantly changing and developing, due to the diversity of opinions associated with the constant change of information. Its validity and accuracy may change over time, depending on new knowledge experiences related to a subject. Experience is the best teacher of knowledge, and since we cannot try everything and apply the experiences of others, therefore, we can rely on They have to access knowledge, so it can be said, "I store my knowledge in others or in my friends" [27].

This is what the connectivism theory in education emphasizes, enhancing students' learning through knowledge and its perception. This is considered a personal network that enables them to gain viewpoints that help in making decisions. It also facilitates the process of researching the huge amount of available data by relying on digital technological communication channels, knowing where to find knowledge is more important than answering how or what that knowledge includes [28]. The connectivism theory Communication theory relies on the use of networks that consist of a group of meeting points (information and data), they are connected to each other by links within the network, in the form of multimedia. Each community of learners is considered a learning network, consisting of a group of individuals, each of whom is considered a learning network that includes experiences, knowledge, skills, etc. As for what is known as connections, it is the learning process itself, and the effort made to connect these meeting points with each other, so that a network of personal knowledge is formed here, of effective participation in the learning process, and this is in line with digital development based on the development of the social web and its applications and software [14]. The learner cannot process all the knowledge and information he needs, he needs other individuals and non-human tools to carry out part of these tasks, connectivism theory indicates that parts of learning occur outside the learner, it believes that the student can store his knowledge with his friends, and this makes. This theory is different from other educational theories such as behaviourism, cognitive and constructivism [29].

Siemens' suggested eight principles of connectivism theory [3, 30, 31]:

- Learning and knowledge consist of diversity of opinions.
- Learning is the process of connecting points of convergence or specialized information.
- Learning can occur in non-human devices.
- The ability to know and learn is more important than the learning content.
- Facilitating continued learning requires maintaining and nurturing communications.
- The ability to see and understand the connections between ideas and concepts is an essential skill.
- Students acquire constantly updated information.
- Decision making is a learning process.

The connectivism theory plays an important role in changing the educational situation and educational design [32]. As indicated by the results of the previously mentioned studies, the design of the electronic collaborative learning environment considering connectivism theory provides integrated learning between formal learning that takes place in traditional ways with participatory digital tools that provide a space for searching for and sharing information.

III. Research Questions

This study came to answer the main study question:

What is the effectiveness of electronic collaborative learning in developing digital thinking skills for primary school digital skills diploma teachers in the light of connectivism theory?

This question stems from the following sub-questions:

1) What is the effectiveness of electronic collaborative learning in developing digital thinking concepts among primary school digital skills diploma teachers in the light of connectivism theory?
2) What is the effectiveness of electronic collaborative learning in developing digital thinking practices among primary school digital skills diploma teachers in the light of connectivism theory?
3) What is the effectiveness of electronic collaborative learning in developing digital thinking trends among primary school digital skills diploma teachers in the light of connectivism theory?

IV. Methods

After defining the objectives and problem of the study, the researchers took the following actions:

Determining the educational content of participatory

learning, which is represented in three units of the advanced digital applications course, which are (advanced Microsoft Word applications, advanced Microsoft Excel applications, and Google educational applications). Then the researchers designed the participatory educational content through the following steps:

- Study and analysis stage: This stage included two main elements: (determining the characteristics of the study sample who were primary school teachers (digital transformation diploma) in addition to identifying their educational needs).
- Design stage: Determining the instructional to be achieved through the electronic collaborative learning environment, identifying content elements, and choosing appropriate educational media.
- Construction stage: The researchers used programs and applications that serve collaborative learning, such as Google educational applications.
- Evaluation stage: The educational content was evaluated in two ways: the formative evaluation for each of the previous stages and the summative evaluation after the completion of the content.
- The use stage: the content was presented to a survey sample of student teachers, and the ease of use was noted, and notes were taken to embarrass the work in the best way.
- Study instruments were distributed.
- The Blackboard platform was used in addition to Google applications.
- It lasted three weeks in the third semester of the academic year 2021–2022, In the first week, the teachers studied advanced Microsoft Word applications, in the second week advanced Microsoft Excel applications, and in the third week, Google educational applications.
- The study instruments were applied again.
- Data were collected and results obtained.

A. Research Design

To answer the questions of the study, a quasi-experimental approach was adopted to know the effectiveness of electronic collaborative learning in developing digital thinking skills among primary school digital skills diploma teachers in the light of connectivism theory.

B. Study Population and Study Sample

The study population consisted of all teachers enrolled in the digital skills diploma for the primary stage program, which is supervised by the Saudi Ministry of Education and taught in some Saudi public universities in the departments of educational technologies (2021–2022), and the study sample consisted of 32 teachers enrolled in the diploma program at Taibah University who registered for the advanced digital applications course, and the sample members were distributed among the study groups in a simple random way, as shown in the Table I below.

TABLE I: DISTRIBUTION OF THE STUDY SAMPLE MEMBERS INTO GROUPS

Method	Total
Electronic Collaborative Learning (ECL)	17
Virtual Classes (VC)	15
Total	32

Sample members were chosen by the intentional method because the researchers is a faculty member at the university and for the cooperation of the Department of Education Technologies to conduct the experiment, in addition to the availability of a sufficient number of study sample members for such type of studies. The equivalence of the study groups was confirmed as shown in Table II:

TABLE II: T-TEST RESULTS FOR TWO INDEPENDENT SAMPLES TO ENSURE THE EQUIVALENCE OF THE TWO EXPERIMENTAL GROUPS ON THE THREE STUDY INSTRUMENTS

Instruments	Groups	N	Mean	Std. Deviation	F	df	Sig.
Digital thinking test	ECL	17	9.52	2.69	1.664	1	0.207
	VC	15	8.13	3.41			
Digital thinking skills observation card	ECL	17	7.29	2.64	0.642	1	0.429
	VC	15	8.26	4.14			
Attitudes toward digital thinking questionnaire	ECL	17	29.00	4.22	1.098	1	0.303
	VC	15	30.53	4.01			

Table II shows that the study groups are equal and on all tools.

Independent Variables: One independent variable, which is the electronic teaching method.

- Electronic Collaborative Learning
- Virtual Classroom.

Dependent variable:

- Digital thinking

C. Instruments

By reviewing and analyzing the study of Abdel [21] and reviewing the instruments for measuring digital thinking in many studies, such as [2, 18, 33] in the field of computational digital thinking, as its procedures and results unanimously assessed the skills of digital thinking through three basic aspects: concepts of digital thinking, practices of digital thinking, and trends towards digital thinking, in order to arrive at a measurement of digital thinking.

Digital thinking test: The researchers prepared a test to measure the concepts of digital thinking among teachers of the Digital Skills Diploma for the primary stage who were registered for the advanced digital applications course which consists of three basic units: advanced Microsoft Word applications, advanced Microsoft Excel applications, and Google educational applications. The test, in its initial form, consisted of 34 multiple-choice questions that necessitate the application of digital thinking skills. The test was presented to a group of reviewers to express their opinions and observations about the test to achieve the validity of the content, where all the required observations were made, and some items of the test questions were modified. In terms of formulations, modification of some options, some linguistic modifications, and deletion of some of them, the number of final exam questions reached 30 questions. Each question has

one mark in the case of the correct answer and zero in the case of incorrect or non-answer. A specification table for the test was created that includes the distribution of digital thinking skills among the three units of the course, as shown in Table III.

TABLE III: TABLE OF SPECIFICATIONS FOR THE TEST ITEMS

Subjects		Advanced Microsoft Word applications		Advanced Microsoft Excel applications		Google educational apps		Total
		Questions	Marks	Questions	Marks	Questions	Marks	
Digital thinking skills	Algorithmic thinking	1	1	3	3	1	1	5
	Abstraction	1	1	1	1	1	1	3
	Analysis	1	1	2	2	3	3	6
	Evaluation	1	1	1	1	2	2	4
	Circular	1	1	3	3	3	3	7
	Simulation	1	1	2	2	2	2	5
Total Questions		6		12		12		30
Percentage %		20%		40%		40%		100%
Total Marks		6		12		12		30
Percentage %		20%		40%		40%		100%

The test was applied to a pilot study from within the study population and from outside its sample, the size of which was 15 teachers, who were chosen by the available method, to estimate the difficulty and discrimination coefficients for the items of the test questions to exclude the unsuitable items. Table IV shows the difficulty coefficients and the discrimination coefficients for each of the items. test questions.

TABLE IV: DIFFICULTY AND DISCRIMINATION COEFFICIENTS FOR THE TEST ITEMS

N	Difficulty Index	Discrimination Index	N	Difficulty Index	Discrimination Index
Q1	0.42	0.34	Q16	0.59	0.55
Q2	0.44	0.51	Q17	0.60	0.66
Q3	0.61	0.40	Q18	0.64	0.51
Q4	0.60	0.59	Q19	0.64	0.43
Q5	0.51	0.59	Q20	0.62	0.74
Q6	0.46	0.40	Q21	0.53	0.64
Q7	0.43	0.44	Q22	0.52	0.54
Q8	0.42	0.59	Q23	0.56	0.64
Q9	0.46	0.40	Q24	0.63	0.57
Q10	0.44	0.44	Q25	0.42	0.51
Q11	0.61	0.48	Q26	0.64	0.43
Q12	0.64	0.66	Q27	0.66	0.58
Q13	0.27	0.44	Q28	0.54	0.57
Q14	0.54	0.62	Q29	0.46	0.40
Q15	0.48	0.48	Q30	0.43	0.64

Table IV shows that the coefficients for the difficulty of the test questions items ranged between 0.42–0.66, and their discrimination coefficients ranged between 0.34–0.66.

To verify the reliability of the test, the researchers used Cronbach's alpha equation for reliability. Its value was 0.78, and thus the test was considered to have high reliability. Based on the results of the reliability and validity coefficients, the test was considered appropriate for the purposes of the study.

Digital Thinking Skills Observation Card: After reviewing the educational literature and previous studies related to the research problem and polling a sample of university professors specialized in the subject of the study, the researchers built a note card for digital thinking practices. Behavioral can observed through the performance of the study sample, and the researchers followed the analytical method that is based on dividing the work into its constituent tasks, which are performed in a sequential sequence to achieve the final goal. Thus, the performance of the study sample (teachers of the digital skills diploma for the primary stage) was observed in digital thinking practices before and after the application of teaching methods (electronic collaborative learning, virtual classrooms).

The observation card was prepared by defining the main skills and their sub-skills. The researchers identified three levels to estimate the performance of the study sample. These levels were (high, medium, low), where the observer puts a mark (X) in front of the skill level, and as was done determine a rating for each level of performance. Table V shows the quantitative estimate of the observation card.

TABLE V: QUANTITATIVE ASSESSMENT OF OBSERVATION CARD

The level of performance	high	medium	low
Quantification	3	2	1

The total score obtained by the student is calculated, thus measuring his performance, and judging the degree of digital thinking practices.

The observation card of digital thinking practices was shown to several referees specialized in educational technologies, computers, teaching methods, measurement and evaluation, and the referees were asked to express their point of view on the clarity of each practice. The referees were also asked to determine the validity of the practices and the extent of the measurement what it was set for, and accordingly, the practices that the referees agreed on were excluded, and the practices that the referees did not agree on were deleted, so that the number of items of the practices of the note card 14 practices.

The validity of the internal consistency of the observation card was also verified by applying it to the exploratory sample, then Pearson correlation coefficients were calculated between the scores of each of the items with the skill to which it belongs. As shown in Table VI.

Table VI Showed that all the correlation coefficients were strong, and a function at the level 0.01. The correlation coefficients ranged between 0.604–0.840, and this confirms that the digital thinking practices observation card has a high degree of internal consistency.

Digital Thinking Skills Observation Card Reliability: To find the reliability of the card, the researchers used the method of agreement of the observers (the researchers and his

colleague) in calculating the stability, and this method requires the use of more than one observer to observe the teachers, and in light of that it can determine the number of times of agreement between the observers, and the number of times of disagreement during the total period of observation, then the percentage of agreement between observers is calculated using the "Cooper" equation to calculate the percentage of agreement, which is:

The percentage of agreement = (the number of times of agreement / (the number of times of agreement + the number of times of disagreement) × 100%

TABLE VI: CORRELATION COEFFICIENTS FOR EACH PRACTICE WITH THE TOTAL SCORE OF OBSERVATION CARD

N	correlation coefficient	Sig.
1	0.685**	0.00
2	0.754**	0.00
3	0.840**	0.00
4	0.621**	0.00
5	0.829**	0.00
6	0.797**	0.00
7	0.827**	0.00
8	0.604**	0.00
10	0.643**	0.00
11	0.648**	0.00
12	0.783**	0.00
13	0.833**	0.00
14	0.745**	0.00

**Correlation is significant at the 0.01 level

Accordingly, the researchers, with the help of a limit of teachers, observed 15 teachers (the exploratory sample), and after applying the mentioned equation, the reliability Cronbach's alpha coefficient was 85.73, which is a high percentage suitable for the purposes of the study.

Questionnaire About Attitude Towards Digital Thinking: The purpose of the questionnaire was to measure the attitudes of primary school digital skills diploma teachers towards digital thinking. To judge it from several aspects, the most important of which are: academic and linguistic integrity, its suitability for students, and the paragraph's affiliation with the skill that it measures, and the amendment was made as appropriate. The researchers also wrote the items of the questionnaire of the type of Likert, so the questionnaire responses were distributed on five levels: Strongly agree (5), agree (4), average (3), disagree (2), strongly disagree (1), and this is reversed in the negative items.

To verify the validity of the questionnaire, correlation coefficients were calculated from the questionnaire items, the attitudes of the digital skills diploma teachers for the primary stage towards digital thinking, as they were applied to an exploratory sample of the teachers (digital skills diploma for the primary stage), which numbered 15 teachers from within the population and outside the study sample, as the correlation coefficient here, it represents the significance of the validity of each paragraph of the questionnaire and the total score, as shown in Table VII.

Table VII shows that all the correlation coefficients were strong, at the level 0.01. The value of the correlation coefficient for the items of questionnaire's attitudes towards total digital thinking ranged between 0.660–0.963, and this confirms that the practice observation card digital thinking has a high degree of internal consistency. The final questionnaire consisted of 20 items. The researchers also made sure that the questionnaire had an appropriate degree of reliability through Cronbach's alpha equation, using the Statistical Software Packages (SPSS) and its value was 0.89.

TABLE VII: CORRELATION COEFFICIENTS OF THE QUESTIONNAIRE

N	correlation coefficient	Sig.
1	0.832**	0.00
2	0.829**	0.00
3	0.751**	0.00
4	0.888**	0.00
5	0.832**	0.00
6	0.898**	0.00
7	0.699**	0.00
8	0.660**	0.00
9	0.780**	0.00
10	0.789**	0.00
11	0.818**	0.00
12	0.963**	0.00
13	0.668**	0.00
14	0.786**	0.00
15	0.829**	0.00
16	0.888**	0.00
17	0.888**	0.00
18	0.788**	0.00
19	0.886**	0.00
20	0.660**	0.00
21	0.854**	0.00

**Correlation is significant at the 0.01 level

V. RESULTS

A. Results of the ECL in Developing Digital Thinking Concepts

To answer the first question, the researchers calculated the means and standard deviations of the study sample's responses to the digital thinking concepts test as shown in Table VIII.

TABLE VIII: POST-TEST SCORES OF TEACHERS' RESPONSE TO THE DIGITAL THINKING CONCEPTS

Groups	means	S.D.	N
ECL	25.7647	2.33263	17
VC	15.0667	3.10453	15
Total	20.7500	6.04819	32

TABLE IX: ANCOVA OF THE POST-TEST SCORES OF TEACHERS' RESPONSE TO THE DIGITAL THINKING CONCEPTS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Groups	916.408	1	916.408	128.166	0.000
Error	207.355	29	7.150		
Total	14912.000	32			

Table VIII shows that there is an apparent discrepancy in the means and standard deviations of the responses of the study sample to the digital thinking concepts test and according to the variable of the electronic teaching method,

and to show the significance of the statistical differences between the arithmetic means, the accompanying analysis of variance test (ANCOVA) was used Table IX.

Table IX shows that there are statistically significant differences at the level of significance (α = 0.5) for the effect of the electronic teaching method on testing the concepts of digital thinking, as the value of *p* was 128.166 and a statistical significance of 0.000, and the differences came in favor of the teaching method through electronic collaborative learning. The earning percentage for black was also calculated to ensure the effectiveness of electronic collaborative learning in testing the concepts of digital thinking for primary school digital skills diploma teachers, and the earning percentage was 1.32. To find out the size of the impact of the electronic collaborative learning method on testing the concepts of digital thinking among teachers of the digital skills diploma for the primary stage, the researchers calculated the effect coefficient of η^2, and the effect argument was large, as it reached the value of $\eta^2 = 0.804$. To verify the effectiveness of the electronic collaborative learning, the researchers calculated the arithmetic mean, standard deviations, and used the t-test for two paired samples.

TABLE X: T-TEST OF THE PRE AND POST TEST SCORES OF TEACHERS' RESPONSE TO THE DIGITAL THINKING CONCEPTS

Data	Test	N	Means	Standard deviations	F	Sig.
Digital thinking concepts test	Pre	17	9.52	2.69	15.58	0.000*
	Post		25.76	2.33		

It is clear from Table X that there are statistically significant differences at the level of significance 0.05 between the mean scores of the group that studied through electronic collaborative learning in the pre and post application of the digital thinking concepts test, in favor of the post test.

B. Results of the ECL in Developing Digital Thinking Practices

To answer the second question, the researchers calculated the arithmetic means and standard deviations of the responses of the study sample on the digital thinking practices card, as shown in Table XI.

TABLE XI: POST-TEST SCORES OF TEACHERS' RESPONSE TO THE DIGITAL THINKING PRACTICES

Groups	means	S.D.	N
ECL	30.7059	4.10434	17
VC	18.0000	3.89138	15
Total	24.7500	7.55197	32

Table XI shows that there is an apparent discrepancy in the arithmetic means and standard deviations of the responses of the study sample on the digital thinking practices card and according to the variable of the electronic teaching method, and to show the significance of the statistical differences between the arithmetic means, the accompanying analysis of variance test (ANCOVA) was used Table XII.

Table XII shows that there are statistically significant differences at the level of significance (α = 0.5) for the effect of the electronic teaching method on the digital thinking practices card, as the value of *p* was 75.340 and a statistical significance of 0.000, and the differences came in favor of the teaching method through electronic collaborative learning. The earning percentage for black was also calculated to ensure the effectiveness of electronic collaborative learning in the digital thinking practices card for teachers of the digital skills diploma for the primary stage. The earning percentage was 1.23. To find out the size of the effect of the electronic collaborative learning method on the digital thinking practices card of the digital skills diploma teachers for the primary stage, the researchers calculated the impact coefficient eta η^2) and the effect argument was large, as it reached the value of the $\eta^2 = 0.728$. To verify the effectiveness of the electronic collaborative learning, the researchers calculated the arithmetic means, standard deviations, and used the t-test for two paired samples.

TABLE XII: ANCOVA OF THE POST-TEST SCORES OF TEACHERS' RESPONSE TO THE DIGITAL THINKING PRACTICES

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Groups	1247.241	1	1247.241	75.340	0.000
Error	480.089	29	16.555		
Total	21370.000	32			

Table XIII shows that there are statistically significant differences at the level of significance 0.05 between the mean scores of the group that studied through electronic collaborative learning in the pre and post application on the digital thinking practices card in favor of the post test.

TABLE XIII: T-TEST OF THE PRE AND POST TEST SCORES OF TEACHERS' RESPONSE TO THE DIGITAL THINKING PRACTICES

Data	Test	N	Means	Standard deviations	F	Sig.
Digital Thinking Skills Observation Card	Pre	17	7.2941	2.64019	22.21	0.000*
	Post		30.7059	4.10434		

C. Results of the ECL in Developing Digital Thinking Trends

To answer the third question, the researchers calculated the arithmetic means and standard deviations of the responses of the study sample to questionnaire, attitudes towards digital thinking, as shown in Table XIV.

TABLE XIV: POST-TEST SCORES OF TEACHERS' RESPONSE TO THE DIGITAL THINKING TRENDS

Groups	means	S.D.	N
ECL	84.2353	5.43748	17
VC	68.2000	9.47327	15
Total	76.7188	11.04020	32

Table XIV shows that there is an apparent discrepancy in the arithmetic means and standard deviations of the responses of the study sample to its questionnaire, attitudes towards digital thinking, and according to the variable of the electronic teaching method.

Table XV shows that there are statistically significant differences at the level of significance (α = 0.5) for the effect of the electronic teaching method on the questionnaire of attitudes towards digital thinking, as the value of *p* was 55.591 and a statistical significance of 0.000, and the differences

came in favor of the teaching method through electronic collaborative learning. The earning percentage for Black was also calculated to ensure the effectiveness of electronic collaborative learning on its questionnaire about trends towards digital thinking among teachers of the digital skills diploma for the primary stage. The earning percentage was 1.25. To find out the size of the impact of the electronic collaborative learning method on its questionnaire, the attitudes towards digital thinking among teachers of the Digital Skills Diploma for the primary stage, the researchers calculated the effect coefficient of η ², and the effect argument was large, as it reached the value of η ²= 0.542. To verify the effectiveness of the electronic collaborative learning, the researchers calculated the arithmetic mean, standard deviations, and used the t- test for two paired samples digital.

TABLE XV: ANCOVA OF THE POST-TEST SCORES OF TEACHERS' RESPONSE TO THE DIGITAL THINKING TRENDS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Groups	2365.998	1	2365.998	55.591	0.000
Error	1234.256	29	42.561		
Total	192123.000	32			

It is clear from Table XVI that there are statistically significant differences at the level of significance 0.05 between the mean scores of the group that studied through electronic collaborative learning in the pre and post application on its questionnaire, attitudes towards digital thinking, in favor of the post test.

TABLE XVI: T-TEST OF THE PRE AND POST SCORES OF TEACHERS' RESPONSE TO THE DIGITAL THINKING TRENDS

Data	Test	N	Means	Standard deviations	F	Sig.
Digital Thinking Skills Observation Card	Pre	17	29.0000	4.22788	98.77	0.000*
	Post		84.2353	5.43748		

VI. DISCUSSION

The results showed that there was an effectiveness of electronic collaborative learning in developing digital thinking skills for primary school digital skills diploma teachers in the light of connectivism theory. This is done by analyzing the responses of the parameters on the three study tools testing the concepts of digital thinking, the card of digital thinking practices, and its questionnaire about trends towards digital thinking.

This result is attributed to the fact that the electronic collaborative learning helped the primary school digital skills diploma teachers to share data and information and propose many ideas that were discussed among them, which led to building and producing knowledge of the content of the advanced digital applications course which includes many concepts of digital thinking from through the collaborative Google educational applications.

As the ease of organizing and arranging information through Google educational applications used in electronic collaborative learning contributed to displaying course information in an easy way that enabled teachers to access topics faster, which was reflected in more effective learning. In addition to the availability of social interaction between teachers which is one of the most important features of electronic collaborative learning, it had a major role in the cognitive growth of the concepts of digital thinking by dividing them into sequential and interrelated sub-practices. The educational topics presented through educational content using Google site, which is characterized by flexibility, considering the characteristics of teachers and the individual differences between them, while ensuring that reinforcement and collective feedback are provided permanently and at every stage of learning which, in turn, is reflected in their digital thinking through their possession of many competencies necessary for digital life and adapting to them to face global developments and to choose and disseminate ideas and knowledge in a digital way.

This type of education also provided opportunities for interaction between Google applications Google Group and teachers, interaction of teachers with their peers, interaction of teachers with the course content, and interaction of teachers with the course teacher, with the ability to control this interaction and display the content in a dynamic and flexible manner according to the responses of the teachers themselves, in addition the possibility of individual and group training and competition between individuals and groups led to a higher degree of proficiency, and with the availability and diversity of multiple information sources that contained many human and non-human meeting points, including materials and multimedia that diversified in presenting the concepts of digital thinking and linking them to the professional life of teachers, as well as the availability of electronic connections enhanced the required outputs, which gave teachers the freedom to access knowledge and information and not be bound by the subjects of the course only, by navigating the digital space and going through experiments within it, and then recording what is useful from the huge amount of information, and sharing it with others helped to acquire the concepts of digital thinking With the ability to evaluate the works, ideas and information presented by others through electronic achievement files and through Google Chat discussions and Google Forms, which they conduct with direct feedback.

Also, Google applications enabled the course instructor to follow up the collaborative tasks so that he could identify the correct and incorrect information contained in the collaborative task while providing appropriate reinforcement through various applications, such as Gmail. This diversity of collaborative alternatives helped to divide the course topics into parts that are compatible with the task Collaborative , organized and made more useful, and storage repositories google drive provided free storage spaces that enable teachers to refer to and share the information stored within them, in addition to the ability of teachers to access and modify files of each person and group such as, Doc, Slides, they have the tools of joint production of knowledge while adhering to the specified times for delivering the collaborative task with the help of Calendar that works to organize the time.

This result is also attributed to the feeling of intimacy among the group of learners through research, freedom and

enjoyment in learning, which led to teachers realizing their needs for digital thinking practices in preparing their lessons and forming their own skill repository that includes many of these practices that can be benefited from in studying the advanced digital applications course and sharing it from through (share) in Google educational applications. This result is also attributed to the novelty of the teaching method that the researchers followed with the teachers, which reflected the learners' satisfaction with the variety of electronic collaborative learning tools, which in turn was reflected in the subject of the study (digital thinking). An incentive for teachers to create and apply many skills in the advanced digital applications course and their continuous follow-up by the course teacher who does not make them feel helpless and frustrated, in addition to the psychological effects possessed by electronic collaborative learning and its ability to attract attention and suspense, all of this encouraged the development of positive attitudes towards digital thinking.

From the point of view of connectivism theory: the communication process that was made available to the learners facilitated the process of continuous learning, the sharing of various learning resources, the organization and mastery of joint activities, and communication and cooperation during electronic collaborative learning and the tools provided by Google educational applications led to the creation of an integrated educational environment that facilitated the exchange of experiences and the acquisition of information concepts and knowledge. And just as the electronic collaborative learning followed the principles of connectivism theory, it allowed teachers to plan and participate in organizing and managing their learning, taking appropriate decisions, and creating collaborative learning habits that enhanced their acquisition of the concepts of digital thinking, through self-interaction with content and thinking about it with complete care, and then identify main ideas, identifying relationships between them and studying activities. The available learning resources lead to conclusions and solutions, and then comes the stage of interaction and sharing with colleagues and providing feedback.

The current study derives its importance from the subject, which emphasizes the thinking skills that teachers must possess Diploma in digital skills for the primary stage, as well as the application of modern theories, such as connectivism theory that promote the integration of digital technology in the educational process, leading to modern methods and strategies, such as Electronic Collaborative Learning, and this study is considered a qualitative addition to the theoretical educational literature with more studies and research that recommended the development of digital thinking skills through electronic collaborative learning environments.

This study is expected to help teachers possess Diploma in digital skills for the primary stage, in developing digital thinking skills due to the importance of this type of thinking.

This study also helps universities, when approving courses, to include the electronic collaborative learning method in their courses, in addition to helping university faculty members to create a collaborative classroom environment that helps the educational process in creating techniques, methods and strategies that help in the development of education.

VII. Conclusion and Recommendations

The current study aimed to find out the effectiveness of Electronic Collaborative Learning (ECL) in developing digital thinking skills among teachers in the light of connectivism theory. To achieve this aim, an educational environment was designed and taught through two methods (Electronic Collaborative Learning (ECL) \ Virtual Classes (VC)). To determine the effectiveness of teaching methods and the difference between them. The researchers used three instruments in the study, the first instrument: testing the concepts of digital thinking skills; the second instrument: a note card for digital thinking practices; and the third instrument: a questionnaire was adapted of teachers' attitudes to digital thinking. The results showed that there was an effectiveness of electronic collaborative learning in developing digital thinking skills for teachers in the light of connectivism theory. The study included the following limitations:

- This study is limited to digital applications course and thus may restrict generalizing the findings of the study to other courses of diploma in digital skills for the primary stage.
- This study is limited to two teaching methods.
- The results of this study only apply to teachers (Diploma in digital skills for the primary stage), in Saudi Arabia at Taibah University from the academic year 2021-2022and therefore cannot be generalized to other teachers.
- This study was conducted not in the natural setting of the class as it was conducted in the computer laboratory.
- The assessment procedures (Study Instruments) maybe insufficient as there were no verbal reports that measure the direct observation of the teacher's interaction and strategy used and its development.

In the light of the research procedures and what the results resulted in; the researchers recommended the following:

- Include digital thinking skills in all digital skills diploma courses for the primary stage.
- Conduct educational studies aimed at developing digital thinking skills in different electronic ways and methods based on modern theories such as communication theory.
- Activat electronic collaborative learning in teaching digital skills diploma courses for the primary stage.
- Pay attention to training students and faculty members in universities on the skills of electronic collaborative learning.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

The three authors have formulated the research methodology, data collection, analysis, contributed to the research, analysis, and presentation of the results. Osamah Aldalalah Analyze the data, wrote the manuscript, and approved the final version.

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