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The effect of the interaction between crowdsourced style and cognitive style on developing research and scientific thinking skills

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Abstract

This study aims to evaluate the effect of the interaction between crowdsourcing style and cognitive style on the development of research and scientific thinking skills among postgraduate students at Alexandria University, by designing an e-learning environment. The current research used an experimental approach with a quasi-experimental design. The research sample consisted of a random sample of 80 postgraduate students who were specializing in mathematics, educational technology, and other areas at the Faculty of Education. The measurement tools consisted of an achievement test, the observation card, cognitive style scale, and scientific thinking scale. Data were analyzed using two-way ANOVA analysis of variance. The results showed that there was a significant difference between crowdsourcing patterns (collaborative/competitive) in favor of the collaborative pattern. There was a significant difference between cognitive style (focusing/scanning) in favor of students who adopted the focusing style. There was a significant effect on the interaction between crowdsourcing patterns and cognitive style for each of the cognitive aspects of research skills in global databases through the e-learning environment based on the crowdsourcing pattern, the observation card of students' performance of those skills, and their scientific thinking. The researchers recommend benefiting from the results of the current research in the design of e-learning environments based on crowdsourced (competitive/collaborative) in general, and crowdsourced collaborative in particular because of their impact on the development of achievement, practical performance, and scientific thinking.

Keywords: crowdsourcing style, e-learning environment, cognitive style, development of research skills, scientific thinking skills, global databases, postgraduate students

INTRODUCTION

In late 2019, an outbreak occurred of the novel virus COVID-19. In a short time, the virus spread around the globe, leading to nearly 120 countries ceasing traditional face-to-face learning methods, and all educational institutions adopted a distance education system. It has become imperative that postgraduate students learn to use available online learning resources to obtain relevant information, and conduct activities related to their course (Shahzad et al., 2020).

Several previous studies (e.g., Al-Ahwal, 2016; Al-Dhafiri & Al-Suwait, 2013; Al-Khathami, 2010; Gouda, 2018; Ibrahim & Abdo, 2016; Melhem, 2011; Sahwan, 2019) have indicated the importance of global databases as sources of electronic information for postgraduate students due to their diversity, up-to-date information, and accessibility. Despite the importance of global databases and the need for postgraduate students to possess the skills to use them, many studies have found weak global database research skills among postgraduates (see Al-Ahwal, 2016; Al-Aklabi, 2009; Al-Azab, 2015; Al-Hayes, 2011; Ibrahim & Abdo, 2016; Gouda, 2018; Sahwan, 2019). Additionally, students lack knowledge regarding what electronic information sources are available within global databases.

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Contribution to the literature

- The current study is similar to some of the previous studies in terms of dealing with crowdsourcing in education. However, it differs in that it explores the effectiveness of the interaction between crowdsourcing pattern (competitive/collaborative) in an e-learning environment and cognitive style (focusing/scanning) on the development of research and scientific thinking skills among postgraduate students.
- This study provides evidence that there was a significant difference between crowdsourcing pattern in favour of the collaborative pattern. There was a significant difference between cognitive style in favour of students who adopted the focusing style. There was a significant effect on the interaction between crowdsourcing pattern and cognitive style for each of the cognitive aspects of research skills in global databases through the e-learning environment, the observation card of students' performance of those skills, and their scientific thinking.

E-learning environments and resources have been diversified and made widely accessible for learners. However, there are some difficulties involved in learning from these sources. For example, there is an abundance of information available, and learners may experience difficulty in identifying appropriate learning resources and interacting with platforms in a meaningful and organized manner. Education, information, and communication technologies have been developed to support e-learning; yet these technologies have not been fully exploited and could be used to further improve educational experiences (Heusler & Spann, 2014).

Some have argued that crowdsourcing could be an effective solution to these issues. This is an effective approach to generating knowledge (Khamis, 2020); it aims to benefit from the experiences of others. Crowdsourced learning is linked to distributed learning tasks, and is an appropriate entry point to support electronic, formative, and online self-assessment. Corneli and Mikroyannidis (2012) concluded that the crowdsourcing model presents all the roles that exist in traditional educational settings and social networking. Crowdsourcing aims to take advantage of people's intellect and experiences and build on them to reach a better result through collected ideas or what is known as "collective intelligence" (Kronk, 2017). Paulin and Haythornthwaite (2016) argued that crowdsourcing offers new approaches to education. However, the use of crowdsourcing in research and development in education is a relatively new topic (Bandyopadhyay et al., 2016; Corneli & Mikroyannidis, 2012).

Since the cognitive style (focusing/scanning) represents an important determinant of individual differences in teaching and learning processes, it is the method preferred by learners for receiving and processing information. This study is concerned with the cognitive style (focusing/scanning), which addresses individual differences between individuals in their capacity and level of focus (Abbas & Al-Jabbas, 2020). According to the cognitive style, scanning students pay attention to a large number of visual elements. Focusing students focus on a limited number of these elements; it is one of the cognitive methods closely related to visual learning as it is concerned with the selective attention of the learner (Al-Khouli, 2002).

The current study seeks to address poor global database research and scientific thinking skills among postgraduate students. The development of scientific thinking skills is one of the educational goals that institutions pursue; they attempt to make educational courses exciting by creating the appropriate conditions for students to acquire and develop scientific thinking skills and solve problems (Al-Hadarb & Al-Kilani, 2018). Consequently, there is a need to address this deficiency by investigating the effect of the interaction between the crowdsourcing style and the cognitive style on the development of research and scientific thinking skills among postgraduate students at Alexandria University. This study addresses the following research questions:

1. What is the effect of interactions between crowdsourcing pattern (competitive or collaborative) in e-learning environments and cognitive style (focusing or scanning) on the development of the cognitive aspect of global database research skills among postgraduate students?
2. What is the effect of interactions between crowdsourcing patterns (competitive or collaborative) in e-learning environments and cognitive style (focusing/scanning) on the development of postgraduate students' performance of global database research skills?
3. What is the effect of interactions between crowdsourcing patterns (competitive or collaborative) in e-learning environments and cognitive style (focusing/scanning) on the development of postgraduate students' scientific thinking skills?

Research Importance

Based on its aims, the importance of the research can be summarized, as follows:

1. Encouraging those responsible for designing and producing crowdsourced e-learning environments to take advantage of competitive

and collaborative crowdsourcing patterns in order to develop scientific thinking and practical skills.

2. Proposing an instructional model for designing e-learning environments based on crowdsourcing which can be used in e-learning technology applications.
3. Emphasizing to designers of e-learning environments the importance of considering the cognitive methods students employ, particularly cognitive style (focusing/scanning), to increase the efficiency of these environments in education.
4. Providing pedagogical and technological research that may help faculty members to consider students' cognitive style in e-learning environments with the aim of helping students to learn more effectively.
5. Directing the interests of education researchers towards empirical research aimed at designing e-learning environments based on (competitive and collaborative) crowdsourcing in order to develop scientific thinking and practical skills.

THEORETICAL FRAMEWORK

Crowdsourcing E-Learning Environments

With the development of the Web and the advent of Web 2.0 (the collaborative web), individuals are able to participate in web editing, which has led to an unprecedented increase in the amount of information on the network. Thus, crowdsourcing portals have emerged. The term 'crowdsourcing' combines the words 'crowd' and 'outsourcing' and hence refers to crowd-based outsourcing. It aims to take advantage of people's knowledge and experiences and build upon them to improve outcomes through the collection of ideas or what is known as 'collective intelligence'. This involves gathering data and information on specific topics or problems from the largest possible number of individuals on the network; it is also an integrated approach to strengthening the performance of the group (Khamis, 2020).

In the field of education, Jiang et al. (2018) defined crowdsourcing as a type of online activity in which, through open and flexible communication, a teacher or educational institution invites a group of individuals to directly assist in the teaching and learning process.

There are three types of crowdsourcing: competitive, collaborative, and co-petition.

Competition-based crowdsourcing

Participants compete on an individual basis to solve a problem or accomplish set tasks. There are many possible solutions, so all solutions offered by participants are evaluated to determine the best one. This is the most commonly and widely used method of crowdsourcing.

Collaborative crowdsourcing

Participants collaborate to accomplish a set task. The main tasks are divided into subtasks which are completed by the participants. This is also known as community-based crowdsourcing or co-creation.

Co-petition crowdsourcing

Co-petition crowdsourcing combines competitive and collaborative crowdsourcing; individuals compete to complete tasks individually, the winner is determined, and these tasks are then combined to form the main task (Heusler & Spann, 2014). The current study is concerned with competitive and collaborative crowdsourcing and its suitability to achieve research objectives.

Theoretical Origins of Crowdsourced E-Learning Environments

Crowdsourcing has multiple theoretical origins. One such theory is activity theory. An activity system is based on participatory rules and standards among members (Frigerio et al., 2018). This is also the case with crowdsourcing, which is a mediating system of activity. Another theory is distributed knowledge theory, which is based on the concept of cognitive systems. A cognitive system is not limited to one individual but a group of individuals who share with each other the tools and the environment while performing a task in a coordinated manner. Hence, distributed knowledge theory investigates the complex interdependence between individuals and tools while performing certain activities. It makes use of concepts from cognitive theories, such as representations and processes, and applies them to cognitive systems through extensive interactions between individuals and tools in a particular activity (Jin et al., 2019).

Cognitive Style (Focusing/Scanning)

Cognitive style represents a learner's cognitive preferences and preferred performance patterns in conceiving and organizing surrounding stimuli. The cognitive style (focusing/scanning) learners adopt is important because this is what they employ when interacting with different stimuli and situations.

Al-Atoum (2010), Al-Jubouri (2010), and Qaoud (2016) all defined a cognitive style (focusing/scanning) as the way in which individuals vary in their degree and intensity of focus. Students with a focusing style are distinguished by clear goals, high degrees of concentration, and decisive responses. Students with a scanning cognitive style are distinguished by speed, superficial viewing, shortness of attention span, and the number of stimuli that are followed up; their decisions are hasty and often flawed.

Criteria for Designing an E-Learning Environment Based on Crowdsourcing (Competitive/Collaborative)

The importance of setting standards in instructional design

Technological products are designed, developed, and evaluated to certain standards. These exclude differences, support, compatibility, and ensure a high degree of quality. They also facilitate monitoring, evaluation, and training (Khamis, 2007).

Sources for the derivation of the current study's criteria

Al-Bassiouni (2012) explained that the design of e-learning environments depends on the philosophy of the systematic approach based on inputs, processes, outputs, feedback, and interaction. Designs should consider ease of access and use for learners. The researchers prepared a list of criteria for designing the e-learning environment by reviewing the literature and previous studies (e.g., Akl & Khamis, 2012; Al-Hinnawi et al., 2013). The researchers included seven main criteria and 57 sub-indicators which included educational standards (educational goals, educational content, characteristics of learners, educational activities, evaluation, and feedback). Technical standards included themes related to the e-learning environment, learning and interactive resources, educational control of the learning environment, and user interface and interaction.

Global Database Research Skills

A skill has been learned when one is able to complete a task in the least possible time with a low amount of effort and the highest level of mastery (Aziz, 1997). A skill includes three aspects:

(1) the cognitive aspect which is concerned with the information and knowledge necessary for the individual to perform a skill measured through achievement tests;

(2) the performance aspect which is concerned with application and practical implementation in the light of what is studied in the cognitive aspect, measured through note and assessment cards; and

(3) the communication aspect which is the individual's ability during the practical implementation of the skill to communicate with it and the trend towards it; it is measured by analyzing trends (Al-Mallah, 2017).

The current study focuses on the cognitive and performance aspects of research skills in the Egyptian Knowledge Bank. These skills were derived from task analysis, the researchers' previous experience in teaching research skills in digital libraries, and the literature (e.g., Ahmed, 2013; Al-Jarf, 2017; Al-Kmaishi, 2014; Said, 2011; Qamouh et al., 2015; Sayed, 2016). An initial list of skills was prepared and presented to a group of specialists in mathematics, educational technology and other areas at the Faculty of Education, and modifications were made. The final list included 10 main skills with sub-skills, such as the skill of using the academic search engine which contained six sub-skills, and the skill of accessing databases which contained 10 sub-skills.

Students' global database research skills greatly affect their academic and professional future; students in general, and postgraduate students in particular, work in technology-rich environments and have diverse technological resources and learning tools that can be applied in real life and play a role in shaping their interaction with information (Ibrahim & Abdo, 2016).

Ibrahim and Abdo (2016) defined a global database as a space that contains multiple electronic media sources and stores, processes, retrieves, and disseminates information required by users. This applies to sources that were originally in electronic form and those that first existed on paper and were converted into electronic sources. Global databases are important for postgraduate students, faculty members, and those interested in scientific research due to their up-to-date information and quick and easy accessibility. Several studies have proven the importance of electronic information sources for scientific research. For example, a study conducted by Saiti and Prokopiadoub (2008) indicated that students' use of the internet, electronic libraries, and search engines improved the ease and speed of data retrieval.

Scientific Thinking

Al-Quran (2017) and Ismail (2018) both defined scientific thinking as a type of organized thinking that aims to study and explain phenomena and discover the scientific rules that govern these through observation, measurement, and experimentation.

The theoretical and philosophical basis of scientific thinking

Constructivist theory is concerned with the scientific thinking of students in the context of interest, the cognitive and mental processes they use, and the importance of creating a learning environment for students to build their knowledge independently. Scientific thinking skills are not acquired passively; the student is active and interactive during the learning process. Constructivist theory believes tribal knowledge to be an important and basic condition in building meaningful learning; experience is the main test of knowledge for students. The meaning formed by students is affected by their previous experiences and the context in which they acquire knowledge. Students use their knowledge and information in building new and modern knowledge (Ismail, 2018).

LITERATURE REVIEW

With the increase in online distributed learning and open learning resources, crowdsourcing is becoming more important in education. Research on crowdsourcing in education began in 2012 and several studies have since been conducted in this field (see Coneli & Mikroyannidis, 2012; Cross et al., 2014; De Alfaro & Shavlovsky, 2014; Faisal et al., 2015; Heusler & Spann, 2014; Paulin & Haythornthwaite, 2016; Skarzauskaite, 2012; Solemon et al., 2013).

A study conducted by Muhammad and Rajab (2022) measured the effectiveness of electronic training environments designed according to electronic crowdsourcing patterns in developing certain learning outcomes. The researchers developed the skills of digital teachers and collective intelligence of science teachers through two patterns of crowdsourcing (internal/external) in electronic training environments. The most notable result was that the external crowdsourcing pattern group outperformed the internal crowdsourcing pattern group.

Another study by Feng et al. (2022) investigated how gamification mechanics drive the contribution to knowledge of problem solvers. It was effectively a study of collaborative knowledge crowdsourcing. According to self-determination theory and related literature, the researchers theorized the mediating roles of three intrinsic motivations (self-esteem, competence enhancement, and a sense of virtual community) and extrinsic motivations in the relationship between three typical gamification mechanics (immersion, social, and achievement) and the knowledge contribution of solvers. They tested their hypotheses using survey data from 386 solvers recruited from a large collaborative knowledge crowdsourcing platform. The results revealed that self-esteem and competence enhancement positively mediated the impact of gamification mechanics on knowledge contribution, whereas extrinsic motivation negatively mediated this impact.

The importance of crowdsourcing in education has been addressed in numerous studies. For instance, De Alfaro and Shavlovsky (2014) developed a crowdsourced platform called 'CrowdGrader', where students could log homework without identifying themselves and then have it reviewed and graded through the use of a crowdsourced peer commentary. Melville (2014) examined peer comments in flipped classes and peer comments on videos. Robb et al. (2015) used crowd commentary to comment on pictures and compared visual and text commentary. Their results indicated a preference for text commentary. Sheinfeld (2016) made use of crowd comments and summaries on interactive videos to investigate the educational process. Morschheuser et al. (2017) employed gamification in the context of crowdsourcing aimed at redirecting external to internal motivation and influenced participants' behavior using game stimuli such as points, badges, and leaderboards. Jin et al. (2019) developed a platform for crowdsourcing to solve problems, which required the application of a set of sequential steps. Often, the learner experienced difficulty in the first step and needed support in determining the steps needed to solve the problem. Thus, the learner involved colleagues in solving the problem, as the learners in this context are the learning sourcing crowd.

RESEARCH HYPOTHESES

A. The hypotheses related to the development of students' achievement of the cognitive aspect related to research skills in global databases:

1. There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the two experimental groups in the post-measurement of the cognitive aspect of research skills for global databases through the e-learning environment based on crowdsourcing pattern. This is due to differences in crowdsourcing pattern (collaborative/competitive).
2. There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the two experimental groups in the post-measurement of the cognitive aspect of research skills for global databases through an e-learning environment based on the crowdsourcing pattern. This is due to the differences in cognitive style (focusing/scanning).
3. There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the experimental groups in the post-measurement of the cognitive aspect of research skills for global databases through an e-learning environment. This is due to the interaction between crowdsourcing pattern (collaborative/competitive) and cognitive style (focusing/scanning).

B. The hypotheses related to the development of students' performance of research skills in global databases:

4. There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the two experimental groups in the post-application of the performance observation card for research skills for global databases through an e-learning environment based on crowdsourcing patterns. This is due

to the differences crowdsourcing pattern (collaborative/competitive).

5. There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the two experimental groups in the post-application of the performance observation card for research skills for global databases through an e-learning environment based on crowdsourcing patterns. This is due to the difference in cognitive style (focusing/scanning).
6. There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the experimental groups in the post-application of the performance observation card for research skills for global databases through an e-learning environment based on crowdsourcing patterns. This is due to the interaction between crowdsourcing pattern (collaborative/competitive) and cognitive style (focusing/scanning).

C. The hypotheses related to the development of scientific thinking among students:

7. There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the two experimental groups in the post-application of the scientific thinking scale through an e-learning environment based on crowdsourcing pattern. This is due to the differences crowdsourcing pattern (collaborative/competitive).
8. There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the two experimental groups in the post-application of the scientific thinking scale through the e-learning environment based on crowdsourcing patterns. This is due to the difference in cognitive style (focusing/scanning), in favor of students with a focusing style.
9. There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the four experimental groups in the post-application of the scientific thinking scale through an e-learning environment based on crowdsourcing patterns. This is due to the interaction between crowdsourcing pattern (collaborative/competitive) and cognitive style (focusing/scanning).

RESEARCH METHODOLOGY

Statement of the Problem

Before conducting this study, we noticed through our work as faculty members at the university that, despite global databases being free to access, students did not use them and thus did not benefit from the information resources available within them. They remained content with superficial theoretical knowledge, despite the importance of scientific and practical knowledge for their specializations. Therefore, the researchers conducted an exploratory study to determine students' opinions about the situation, and the knowledge and skills needed to use and employ global databases in their studies and research. The researchers conducted open interviews with a sample of 50 post-graduate students from the Faculty of Specific Education at Alexandria University. The interview questions were, as follows:

1. Can you describe your ability to carry out scientific research procedures?
2. What is your ability to conduct scientific research on global databases?
3. What are the most important databases you use in scientific research?
4. What steps of scientific thinking must you follow to conduct scientific research?
5. Describe your need to learn the skills required to employ global databases in scientific research
6. What is your need to learn the skills required to employ global databases in scientific research?

The results revealed that 96% experienced difficulty using global databases and thus did not use the information sources available. Furthermore, all interviewees expressed a desire to develop the knowledge and skills necessary to use global databases. This problem was further exacerbated by the COVID-19 health crisis. There was an outbreak of the novel virus COVID-19 at the end of 2019 and in a short time it had spread around the world, resulting in nearly 120 countries ceasing traditional face-to-face learning methods, and all educational institutions shifting to a distance education system. It has become imperative for postgraduate students to learn to use the online learning resources that are available to obtain relevant information and conduct all activities related to their course (Shahzad et al., 2020).

Research Approach

The current study used an experimental approach with a quasi-experimental design to measure the effect of the interaction between crowdsourcing patterns (competitive/collaborative) in e-learning environments and cognitive style (focusing/scanning) on the development of postgraduate students' global database research and scientific thinking skills.

Research Sample

The research sample consisted of a random sample of 80 postgraduate students specializing in mathematics, educational technology, and other areas at the Faculty of

Education. After dividing them into (focusing/scanning) students, they were separated into four experimental groups (2×2 factorial design), each of which consisted of 20 students, as follows:

1. **Group (1):** 'Focusing' students who learn in a competitive crowdsourcing style
2. **Group (2):** 'Focusing' students who learn in a collaborative crowdsourcing style
3. **Group (3):** 'Scanning' students who learn in a competitive crowdsourcing style
4. **Group (4):** 'Scanning' students who learn in a collaborative crowdsourcing style

In conducting this study, the researchers had to address four of the most important ethical issues. Firstly, the researchers informed the participants as fully as possible as to the purpose of the research. Secondly, the researchers ensured that all participants signed the informed consent form, without coercion, and were given a copy of the consent document. Thirdly, the researchers ensured that each participant's identity alongside their personal information remained anonymous. Therefore, during the translation process, their names were not included. Finally, the researchers made it clear to all participants that they were volunteers and could withdraw their participation at any time without penalty. To achieve the research objectives, the researchers followed the procedure outlined below.

First: Determining the Skills Required for Searching Global Databases

To determine the research skills required for global databases, the researchers analyzed basic tasks, and prepared an initial list of research skills that could be applied by postgraduate students at the Faculty of Specific Education, University of Alexandria to global databases available through the Egyptian Knowledge Bank. Skills were divided into 10 basic skills which were further divided into 86 sub-skills. These skills included creating an account on the Egyptian Knowledge Bank, using an academic search engine, accessing global databases, identifying relevant databases, selecting appropriate keywords, connect their keywords, limiting their searches using basic search limiters, using advanced search skills to refine their searches, displaying search results, and save and share search results for future use. Main tasks were divided into subtasks using the hierarchy. A list of main tasks and subtasks was prepared. The task list was presented to a group of specialists to ensure that the correct linguistic formulations had been employed. Some amendments were suggested by the reviewers, such as merging or deleting some tasks, and modifying the linguistic wording of others. These amendments were made to produce the final list.

Second: Determining the Criteria for Designing an E-Learning Environment Based on Crowdsourcing Patterns (Competitive/Collaborative)

The researchers extracted a set of criteria and indicators from the literature which addressed the design of e-learning environments; the list included seven main criteria and 57 sub-indicators. The researchers presented a list of the initial criteria to a group of specialists to obtain their opinions on the list. They suggested merging some criteria with other similar criteria, modifying the wording of some phrases, adding some indicators to some criteria, and deleting or modifying some indicators.

Third: The Educational Design Model for the E-Learning Environment Based on Crowdsourcing (Competitive/Collaborative)

To measure the impact of interactions between crowdsourcing (competitive/collaborative) in e-learning environments and cognitive style (focusing/scanning) on the development of research skills for global databases and scientific thinking among postgraduate students, and then design an e-learning environment, the researchers examined several models of instructional design. The ADDIE universal design model (analysis, design, development, implementation, and evaluation) was adopted and comprised the following stages:

1. **The first stage (analysis):** This stage included the following steps: defining general objectives, defining educational problems, defining educational content, analyzing student characteristics, and defining learning activities and tasks.
2. **The second stage (design):** This stage included the following steps: defining educational goals, managing the user, managing educational tasks, managing contribution, and managing the workflow.
3. **The third stage (development):** In this step, the available resources were examined. Following this, the requirements and capabilities needed to design an environment based on crowdsourcing (competitive/collaborative) were determined by specifying the crowding platform (Microsoft Teams).

   Microsoft Teams includes several integrated online tools and a set of e-learning systems and tools, such as content management systems (CMS) and learning management systems (LMS), that can be employed in e-learning environments. It allows faculty members to manage student registration, follow-up learning activities, and manage various tests. It also enables them to control the educational process and content, and allows students to participate in chats and meetings, make audio and video calls, share and store documents and files, and retrieve information and notes together in a team hub. All of these features made Microsoft Teams an appropriate choice to achieve the goals of this study through its use as a competitive and collaborative crowdsourcing platform.

4. **The fourth stage (implementation):** In this stage, actual teaching takes place, and the aim is to enhance the internal efficiency and effectiveness of the crowdsourcing platform (Microsoft Teams) in order to improve students' understanding and support their mastery of goals. This stage included conducting a pilot test of the crowdsourcing platform (Microsoft Teams) at a micro level on a sample of 10 post-graduate students who were divided into two equal groups. The first group was taught through the e-learning environment based on the competitive crowdsourcing style, and the other group was taught through the e-learning environment based on the collaborative crowdsourcing style. The measurement tools were applied both before and after teaching took place. The internal effectiveness of the two e-learning environments was calculated using the modified Blake equation and was equal to 1.6. This confirmed the internal effectiveness of the two learning environments when applied to the basic sample for research. At this stage, the researchers ensured that the materials and activities of teaching accompanying the crowdsourcing platform (Microsoft Teams platform) worked well with students, and that faculty members and students were able to use the crowdsourcing platform with ease. The researchers also ensured that appropriate conditions were created in terms of the availability of hardware and various other aspects of support.
5. **The fifth stage (evaluation):** This stage aimed to ensure the validity of the e-learning environment using Microsoft Teams to crowdsource (competitive/collaborative) by presenting it to a group of arbitrators in the field of educational technology who assessed it using a relevant list of criteria. Based on this, the researchers made any necessary modifications to the e-learning environment and prepared it in its final form.

Fourth: Building and Adjusting Measurement Tools

A. **Cognitive style scale (focusing/scanning) prepared by Qaoud (2016):** The scale measures cognitive style (focusing/scanning). This is a measure of the preferred personal style of graduate students when attending to a number of elements in a field. The validity and reliability of the scale were calculated using two methods:

1. the re-application method, for which the reliability was found to be 0.83 and
2. the Cronbach's alpha method, for which the reliability coefficient was found to be 0.87, both of which are acceptable levels of reliability.

The final scale consisted of 20 items and the maximum score reached in answering the items and phrases on the scale was 20 degrees.

B. **Cognitive achievement test related to research skills in global databases:** This test aimed to identify the extent to which postgraduate students at the Faculty of Specific Education acquired cognitive aspects related to research skills for global databases. The test vocabulary was designed and formulated using two types of objective questions: multiple-choice questions (25 items) and true and false questions (25 items). The test instructions were formulated, and the scores calculated. The maximum possible score when answering the test items and phrases was 50. The test validity was calculated, and its reliability coefficient was found to be 0.86, indicating that the test had an acceptable degree of reliability.

C. **An observation card for postgraduate students' performance of research skills for global databases:** This aimed to identify the extent to which postgraduate students at the Faculty of Specific Education, Alexandria University were able to apply research skills to international databases. The observation card was prepared in its initial form in light of the educational objectives and analysis of the tasks and content; it consisted of 10 basic skills and the maximum possible score was 258. The observation card was then adjusted to ensure its appropriateness in terms of validity and reliability.

D. **A measure of scientific thinking:** This scale aimed to measure the scientific thinking skills of postgraduate students at the Faculty of Specific Education, Alexandria University. The vocabulary of the scale was formulated by determining the axes used to define the problem, choosing appropriate alternatives to solve this problem, testing the validity of hypotheses, drawing conclusions, and generalizing (in the form of exercises). Each exercise was formulated as follows: an introduction was placed at the beginning of the scale followed by a set of alternatives from which the student chose the one that best matched the introduction. The scale phrases in their initial form amounted to 52 exercises distributed evenly across the skills included in the scale. The maximum possible score obtained when answering the scale phrases

Table 1. Arithmetic means, standard deviations, & "p" values for students' scores in pre-application of achievement test

Sources of variation	Sum of squares	Degrees of freedom	Mean square	Value of p	Significant level
Crowdsourcing pattern	0.013	1	0.013	0.002	0.966
Cognitive style	0.013	1	0.013	0.002	0.966
Crowdsourcing pattern*cognitive style	1.013	1	1.013	0.151	0.699
Error	510.450	76	6.716		
Total	43,803.0				

Table 2. Arithmetic means, standard deviations, & "p" values for students' scores in pre-application of skill performance observation card

Sources of variation	Sum of squares	Degrees of freedom	Mean square	Value of p	Significant level
Crowdsourcing pattern	0.450	1	0.450	0.014	0.907
Cognitive style	0.000	1	0.000	0.000	1.000
Crowdsourcing pattern*cognitive style	0.050	1	0.050	0.002	0.969
Error	2,500.70	76	32.904		
Total	277,218.0				

was 52. The scale was adjusted by calculating its validity and reliability, which was found to 0.85 and is an acceptable value.

Fifth: The Exploration of the Two Learning Environments Based on Crowdsourcing

One objective at this stage was to determine the extent to which the two e-learning environments were suitable for students in relation to ease of use, the clarity of the instructions, the accuracy of the linguistic and scientific formulation of the text, the appropriateness of the shape and size of the font, and the quality and clarity of the images.

Sixth: The Basic Experiment

The research experiment was conducted according to the following procedures:

1. **Preparing for the experiment:** Content, tasks, and educational activities were prepared that provided educational content to students in the research sample through the Microsoft Teams platform; two teams were created on Microsoft Teams. The first team was based on the pattern of competitive crowdsourcing and consisted of 40 students; 20 of whom adopted a focusing cognitive style, and 20 adopted a scanning cognitive style. The second team was divided into collaborative group. There were 40 students: 20 of them adopted a focusing cognitive style, and 20 adopted a scanning cognitive style. The students of this team were divided into 10 participatory groups, each comprising four persons. A channel was created for each group on this team within the Microsoft Teams platform. Each group crowdsourced based on the tasks that were sent to them via the platform. A leader was assigned to each group and tasked with distributing roles and tasks among the group and publishing the crowd results on their channel wall. These were commented on by researchers through available responses on publications on the Microsoft Teams platform.
2. **The research tools:** The achievement test, the observation card, and the scientific thinking test. were pre-applied to the students and their scores were calculated in preparation for statistical analysis.
3. **Ensuring equality in the research groups:** To ensure equivalence of the research groups with respect to the pre-application of the achievement test, the performance observation card, and the scientific thinking scale, the researchers conducted a two-way ANOVA to calculate the arithmetic mean and standard deviation of the scores and the value of 'P' to test the significance of the average differences in the achievement test scores, as illustrated in the following tables:
   (a) The equality of the research groups with respect to the interaction effect associated with the achievement test is illustrated in **Table 1**.

   Table 1 presents the values of p (equal to 0.151) and statistical significance (0.699). There were no statistically significant differences at the ≤0.05 level between the average grades of postgraduate students in the pre-application of the achievement test, due to the main effect of the interaction between (the crowdsourcing pattern/cognitive style) therefore, any differences that occurred can be attributed to the different experimental treatments applied.

   (b) The parity of the research groups regarding the interaction effect associated with skill performance observation card is illustrated in **Table 2**.

   Table 2 presents the values of p (0.002) and statistical significance (0.969). Thus, there were no statistically significant differences between the average scores of postgraduate students in the pre-application of the skill performance observation card. Therefore, any differences

Table 3. Arithmetic means, standard deviations, & "p" values for students' scores in pre-application of scientific thinking scale

Sources of variation	Sum of squares	Degrees of freedom	Mean square	Value of p	Significant level
Crowdsourcing pattern	0.113	1	0.113	0.031	0.860
Cognitive style	0.113	1	0.113	0.031	0.860
Crowdsourcing pattern*cognitive style	0.613	1	0.613	0.171	0.681
Error	272.550	76	3.586		
Total	40,459.0				

Table 4. Results of two-way analysis of variance between two independent variables on the achievement side of the skill of searching global databases

Sources of variation	Sum of squares	Degrees of freedom	Mean square	Value of p	Significant level	Significant at ≤0.05 level
Crowdsourcing pattern	423.200	1	423.200	214.851	0.00	Significant
Cognitive style	328.050	1	328.050	166.545	0.00	Significant
Crowdsourcing pattern*cognitive style	57.800	1	57.800	29.344	0.000	Significant
Error	149.700	76	1.970			
Total	141,240.000					

that occurred can be traced back to the different experimental treatments applied.

(c) Equivalence of research groups for the interaction effect related to the scientific thinking scale, as shown in Table 3.

Table 3 lists the values of p (0.171) and statistical significance (0.681). There were no statistically significant differences between the average scores of postgraduate students in the pre-application of the scientific thinking scale. Thus, any differences that occurred can be traced back to the differences in the experimental treatments applied.

RESULTS

The first question was answered by testing the first, second, and third hypotheses.

Presentation of the Results Related to Students' Achievement of the Cognitive Aspects Related to Research Skills in Global Databases

Table 4 presents the results of the two-way ANOVA regarding the cognitive achievement of research skills for global databases.

As indicated in Table 4, the results can be reviewed in terms of the effect of the two independent variables and the interaction between them regarding the first three hypotheses, which are, as follows:

The first hypothesis

'There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the two experimental groups in the post-measurement of the cognitive aspect of research skills for global databases through the e-learning environment based on crowdsourcing pattern. This is due to differences in crowdsourcing pattern (collaborative/competitive)'.

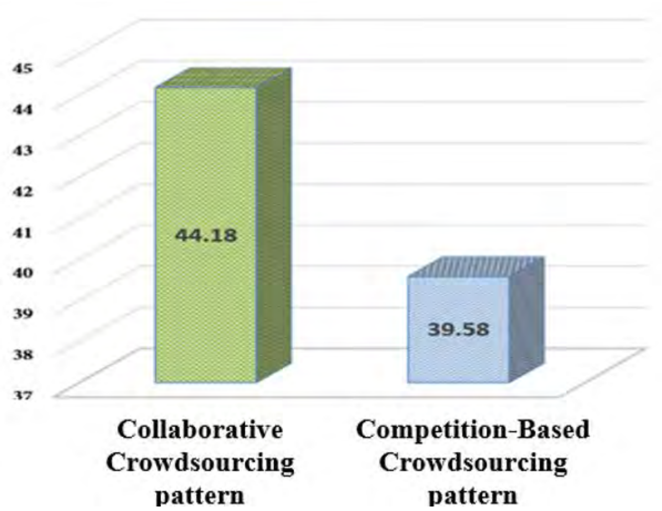

Figure 1. The averages of the two experimental groups in the post-measurement of the acquisition of cognitive aspects related to research skills for global databases due to different crowdsourcing patterns

Extrapolating the results in Table 4, there was a statistically significant difference between the mean scores in the cognitive achievement of research skills for global databases as a result of the different crowdsourcing patterns in e-learning environments in favor of the experimental group (using the collaborative pattern).

Thus, the null hypothesis was rejected, and an alternative hypothesis was accepted, namely, that 'There are statistically significant difference at the ≤0.05 level between the mean scores of the two experimental groups in the post-measurement of the cognitive aspects of research skills in global databases through the e-learning environment based on the crowdsourcing pattern. This is due to differences in crowdsourcing pattern (collaborative/competitive), in favor of a collaborative pattern' (Figure 1).

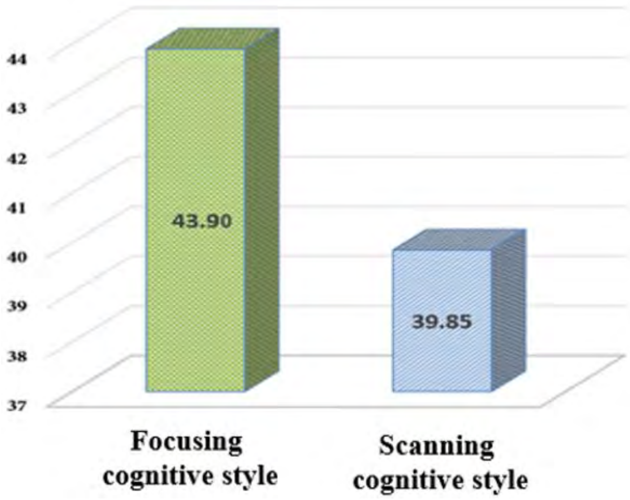

Figure 2. Average scores of the two experimental groups for the acquisition of the cognitive aspects of research skills for global databases through an e-learning environment

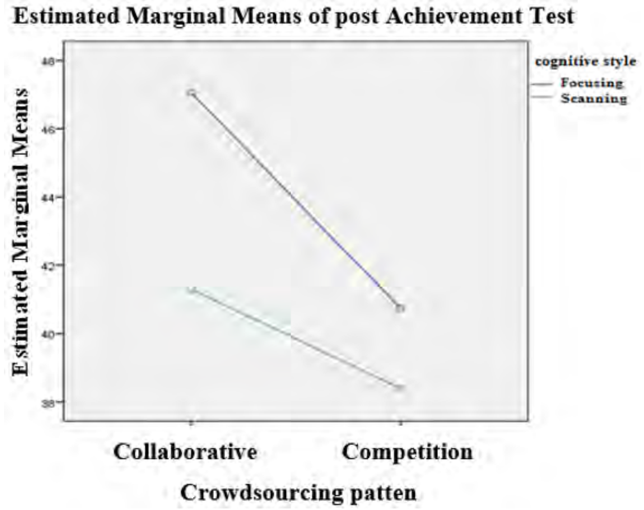

Figure 3. The arithmetic averages of students' scores in the post-application of the cognitive test for the interaction between the two independent variables

The second hypothesis

'There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the two experimental groups in the post-measurement of the cognitive aspect of research skills for global databases through an e-learning environment based on the crowdsourcing pattern. This is due to the differences in cognitive style (focusing/scanning)'.

There was a statistically significant difference between the average scores of students in the cognitive achievement of research skills for global databases. This was a result of differences in cognitive style (focusing/scanning) in favor of students with a focusing style. The average score of these students was 43.90 and the average score of students with a scanning style was 39.85.

Thus, the null hypothesis was rejected, and an alternative hypothesis was accepted: 'There are statistically significant difference at the ≤0.05 level between the mean scores of the two experimental groups in post cognitive aspects of research skills for global databases through an e-learning environment based on the crowdsourcing pattern. This is due to differences in cognitive style (focusing/scanning) in favor of students with a focusing style' (**Figure 2**).

The third hypothesis

'There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the experimental groups in the post-measurement of the cognitive aspect of research skills for global databases through an e-learning environment. This is due to the interaction between crowdsourcing pattern (collaborative/competitive) and cognitive style (focusing/scanning)'.

As shown in **Table 4**, the value of p was equal to 29.344 and the value of the statistical significance was 0.000, which is statistically significant at the ≤0.05 level. Therefore, the null hypothesis was rejected, and an alternative hypothesis was accepted: 'There are statistically significant differences at the ≤0.05 level between the mean scores of the students of the four experimental groups in the post-measurement of the cognitive aspect of research skills for global databases through the e-learning environment. This is due to the interaction between crowdsourcing pattern (collaborative/competitive) and cognitive style (focusing/scanning) (**Figure 3**).

The second question was answered by testing the fourth, fifth, and sixth hypotheses.

Presentation of the Results Related to the Development of Students' Performance of Research Skills in Global Databases

Table 5 presents the results of the two-way ANOVA for the performance observation card for research skills for global databases.

The results can be reviewed in terms of the effect of the two independent variables and the interaction between them regarding the fourth, fifth, and sixth hypotheses, which were, as follows:

The fourth hypothesis

'There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the two experimental groups in the post-application of the performance observation card for research skills for global databases through an e-learning environment based on crowdsourcing patterns. This is due to the differences crowdsourcing pattern (collaborative/competitive)'.

Table 5. Results of the two-way analysis of variance between the two independent variables on the performance observation card for research skills for global databases

Sources of variation	Sum of squares	Degrees of freedom	Mean square	Value of p	Significant level	Significant at ≤0.05 level
Crowdsourcing pattern	1,805.000	1	1,805.000	112.803	0.000	Significant
Cognitive style	1,411.200	1	1,411.200	88.193	0.000	Significant
Crowdsourcing pattern*cognitive style	211.250	1	211.250	13.202	0.001	Significant
Error	1,216.100	76	16.001			
Total	4,809,584.00					

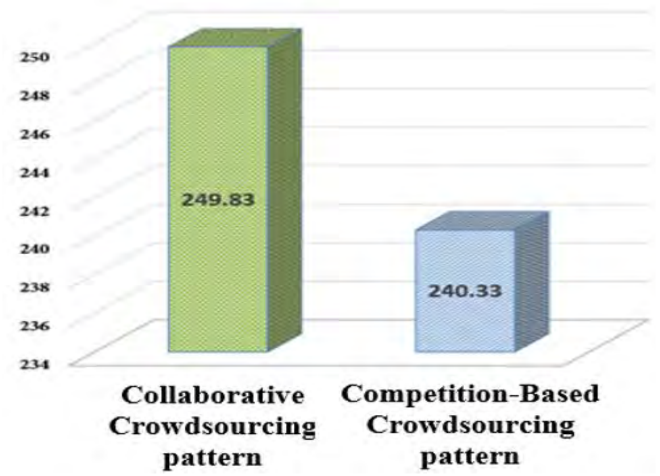

Figure 4. The average scores of the two experimental groups in the post-application of the performance observation card for research skills for global databases due to different crowdsourcing patterns

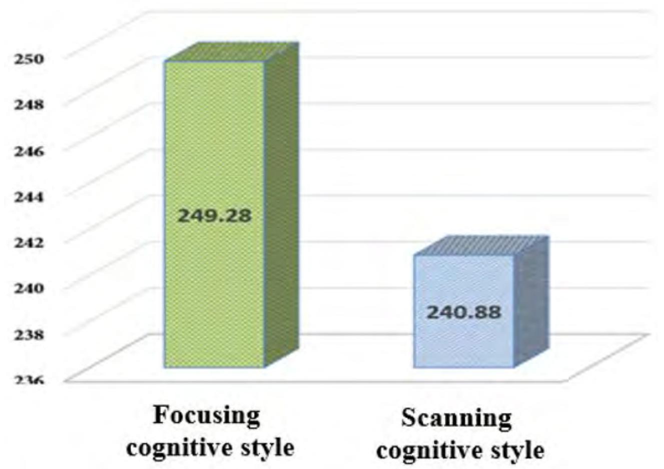

Figure 5. The average scores of the two experimental groups in the post-application of the performance observation card for research skills for global databases due to differences in cognitive style

As shown in **Table 5**, there was a statistically significant difference between the average scores of students for the performance observation card for research skills for global databases as a result of different crowdsourcing patterns.

Thus, the null hypothesis was rejected, and an alternative hypothesis was accepted: 'There are statistically significant difference at the ≤0.05 level between the mean scores of the students of the two experimental groups in the post-application of the performance observation card for research skills for global databases through an e-learning environment based on crowdsourcing patterns. This is due to differences in crowdsourcing pattern (collaborative/competitive) in favor of a collaborative pattern' (**Figure 4**).

The fifth hypothesis

'There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the two experimental groups in the post-application of the performance observation card for research skills for global databases through an e-learning environment based on crowdsourcing patterns. This is due to the difference in cognitive style (focusing/scanning)'.

There was a statistically significant difference between the mean scores of students in the post-application of the performance observation card for research skills for global databases as a result of differences in cognitive style (focusing/scanning) in favor of students with a focusing style (249.28); the average score of these students was 240.88.

Based on these results, the null hypothesis was rejected, and an alternative hypothesis was accepted: 'There are statistically significant difference at the ≤0.05 level between the mean scores of the students of the two experimental groups in the post-application of the performance observation card for research skills in global databases through an e-learning environment based on crowdsourcing patterns. This is due to differences in cognitive style (focusing/scanning) in favor of students with a focusing style' (**Figure 5**).

The sixth hypothesis

'There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the experimental groups in the post-application of the performance observation card for research skills for global databases through an e-learning environment based on crowdsourcing patterns. This is due to the interaction between crowdsourcing pattern (collaborative/competitive) and cognitive style (focusing/scanning)'.

Table 6. Results of the two-way analysis of variance between the two independent variables on the post-application of the scientific thinking scale

Sources of variation	Sum of squares	Degrees of freedom	Mean square	Value of p	Significant level	Significant at ≤0.05 level
Crowdsourcing pattern	567.113	1	567.133	132.109	0.000	Significant
Cognitive style	678.613	1	678.613	158.083	0.000	Significant
Crowdsourcing pattern*cognitive style	21.013	1	21.013	4.895	0.030	Significant
Error	326.250	76	4.293			
Total	160,815.000					

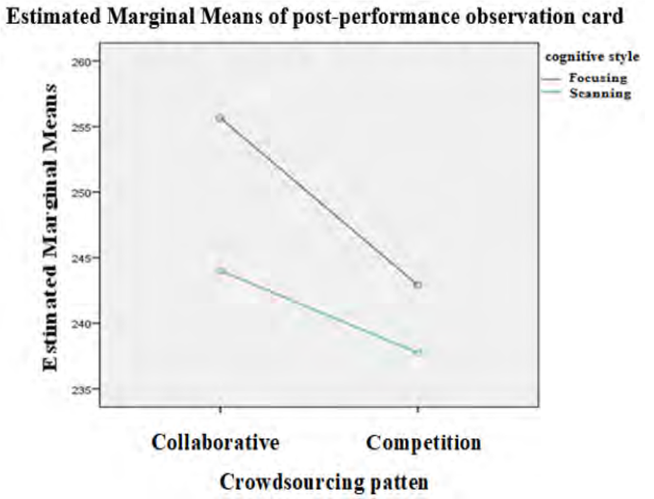

Figure 6. The mean scores of the experimental groups in the post-application of the performance observation card for research skills for global databases due to the interactions between the two independent variables

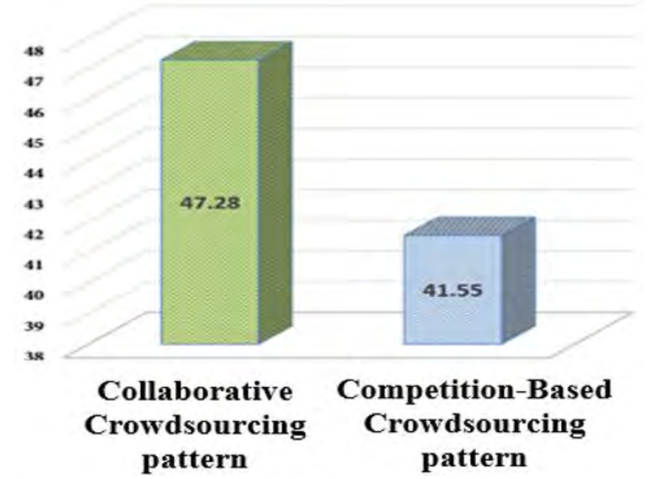

Figure 7. The average scores of the two experimental groups in the post-application of the scientific thinking scale due to different crowdsourcing patterns

As shown in **Table 5**, the value of p was equal to 13.202 and the value of the statistical significance was 0.001, which was statistically significant at a ≤0.05 level. Therefore, the null hypothesis was rejected, and an alternative hypothesis was accepted: 'There are statistically significant differences at the ≤0.05 level between the mean scores of the students of the experimental groups in the post-application of the performance observation card for research skills for global databases through an e-learning environment based on crowdsourcing style. This is due to the interaction between crowdsourcing pattern (collaborative/competitive) and cognitive style (focusing/scanning)' (**Figure 6**).

The third question was answered by testing the seventh, eighth, and ninth hypotheses.

Presentation of the Results Related to the Development of Scientific Thinking Among Students

Table 6 presents the results of the two-way ANOVA on the post-application of the scientific thinking scale.

The results can be reviewed in terms of the effect of the two independent variables and the interaction between them regarding the seventh, eighth, and ninth hypotheses, which were, as follows:

The seventh hypothesis

'There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the two experimental groups in the post-application of the scientific thinking scale through an e-learning environment based on crowdsourcing pattern. This is due to the differences crowdsourcing pattern (collaborative/competitive)'.

As shown in **Table 6**, there was a statistically significant difference between the mean scores of students in the post-application of the scientific thinking scale as a result of different patterns of crowdsourcing.

Therefore, the null hypothesis was rejected, and an alternative hypothesis was accepted: 'There are statistically significant differences at the ≤0.05 level between the mean scores of the students of the two experimental groups in the post-application of the scientific thinking scale through an e-learning environment based on crowdsourcing pattern. This is due to differences in crowdsourcing pattern (collaborative/competitive) in favor of a collaborative pattern' (**Figure 7**).

The eighth hypothesis

'There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the two experimental groups in the post-application of

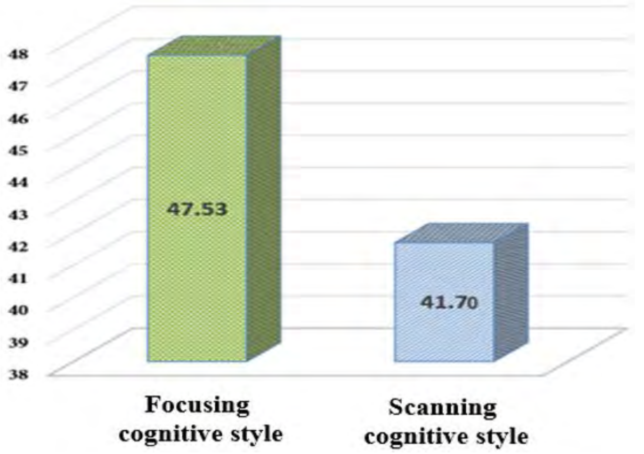

Figure 8. The average scores of the two experimental groups in the post-application of the scientific thinking scale due to differences in cognitive style

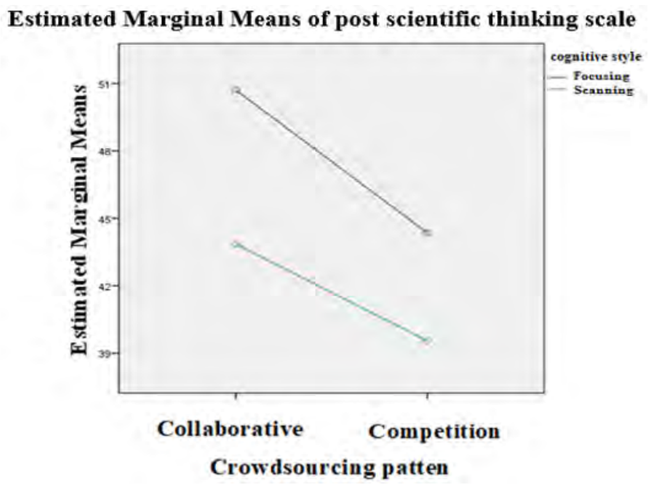

Figure 9. The mean scores of the experimental groups in the post-application of the scientific thinking scale due to the interactions between the two independent variables

the scientific thinking scale through the e-learning environment based on crowdsourcing patterns. This is due to the difference in cognitive style (focusing/scanning), in favor of students with a focusing style'.

There was a statistically significant difference between the mean scores in the post-application of the scientific thinking scale as a result of differences in cognitive style (focusing/scanning) in favor of students with a focusing style. The average score of these students was 47.53 and the average score of the students with a scanning style was 41.70.

Thus, the null hypothesis was rejected, and an alternative hypothesis was accepted: 'There are statistically significant difference at the ≤0.05 level between the mean scores of the students of the two experimental groups in the post-application of the scientific thinking scale through an e-learning environment based on crowdsourcing patterns. This is due to differences in cognitive style (focusing/scanning) in favor of students with a focusing style' (**Figure 8**).

The ninth hypothesis

'There are no statistically significant differences at the ≤0.05 level between the mean scores of the students of the four experimental groups in the post-application of the scientific thinking scale through an e-learning environment based on crowdsourcing patterns. This is due to the interaction between crowdsourcing pattern (collaborative/competitive) and cognitive style (focusing/scanning)'.

As shown in **Table 6**, the value of p was equal to 4.895 and the value of the statistical significance was 0.030, which was statistically significant at a ≤0.05 level. Therefore, the null hypothesis was rejected, and an alternative hypothesis was accepted: 'There are statistically significant differences at the ≤0.05 level between the mean scores of the students of the experimental groups in the post-application of the scientific thinking scale through the e-learning environment based on crowdsourcing patterns. This is due to the interaction between crowdsourcing pattern (collaborative/competitive) and cognitive style (focusing/scanning)' (**Figure 9**).

DISCUSSION

Regarding the results for the first hypothesis, the researchers attribute this to the fact that the collaborative crowdsourcing pattern aided the exchange of opinions and experiences between group members as they performed collaborative tasks using the Microsoft Teams platform. This enriched the learning process and thus helped to increase the cognitive achievement of these students, unlike students in the competitive crowdsourcing group who did not benefit from this exchange of opinions and experiences and focused instead on crowdsourcing competition.

The results of the current research agree with the conclusions of Corneli and Mikroyannidis (2012) that the crowdsourcing model presents all the roles that exist in e-learning environments and social networks. They are also consistent with the results of Paulin and Haythornthwaite (2016) who contended that crowdsourcing provides new approaches to achieve the objectives of teaching and learning processes, and with the findings of Bandyopadhyay et al. (2016) and Corneli and Mikroyannidis (2012) that learning based on crowdsourcing is linked to distributed learning tasks and is an appropriate approach for supporting electronic assessment, formative assessment, and online self-assessment.

The results are also in agreement with several other studies (see De Alfaro & Shavlovsky, 2014; Jin et al., 2019; Melville, 2014; Morschheuser et al., 2017; Robb et al., 2015; Sheinfeld, 2016), confirming the effectiveness of crowdsourced platforms in developing student achievement.

Regarding the results for the second hypothesis, the researchers attributed these to the fact that the focusing students were highly attentive and concentrated on the stimuli around them; they utilized the tools of the Microsoft Teams platform and crowdsourced in a way that was related to research skills for the global databases available through the Egyptian Knowledge Bank. They did not make judgments and decisions hastily. Conversely, the scanning students were quick to examine educational situations but paid less attention to them, which made them more prone to errors and negatively affected their cognitive achievement compared to focusing students.

The results of the current study are consistent with those of other studies (see Al-Atoum, 2010; Al-Jubouri, 2010; Qaoud, 2016) in those students using a focusing method had clear objectives and exhibited high degrees of concentration and deliberation in responding to and solving problems and making decisions. Conversely, students with a scanning cognitive style prioritized speed, viewed items superficially, and had short attention spans in terms of the duration of attention and the number of stimuli that were followed up, as a result of which they made hasty and error-prone decisions.

Regarding the results for the third hypothesis, these confirm that crowdsourcing patterns (competitive/collaborative) utilized students' skills and abilities, increased student engagement, and enhanced student satisfaction with the learning process.

With respect to the results for the fourth hypothesis, the researchers attributed these to the contribution made by collaborative crowdsourcing to the development of students' research skills for global databases in the collaborative learning group. This group had less fear of failure as member provided each other with feedback; this was not available for those in the competitive group.

The results of the current research are consistent with numerous studies that have examined the use of crowdsourcing in e-learning systems to perform tasks such as creating educational content (Karataev & Zadorozhny, 2017), determining appropriate activities for different learners (Rizk et al., 2019) and providing educational services to users (Barbosa et al., 2014). They are also consistent with the findings of De Alfaro and Shavlovsky (2014), Jin et al. (2019), Melville (2014), Morschheuser et al. (2017), Robb et al. (2015), and Sheinfeld (2016). This confirms the effectiveness of crowdsourced platforms in promoting skills development among students.

The researchers attributed the results of the fifth hypothesis to the fact that students with a focusing style concentrated on a limited number of content elements and displayed high degrees of concentration. Crowdsourcing thus helped them to be more attentive and focused, which was particularly helpful for these students as the tasks they undertook depended on the fragmentation and simplification of skills learning, and then presenting these tasks in a logical and clear sequence to master the skill of searching global databases.

These results are consistent with those of other studies (Al-Atoum, 2010; Al-Jubouri, 2010; Qaoud, 2016) in those students with a focusing style exhibited selective attention. They chose appropriate learning resources relevant to the tasks according to their knowledge and skills, which allowed them to better and more accurately handle the skills required in searching global databases.

Regarding the results for the sixth hypothesis, both crowdsourcing styles (competitive/collaborative) had a positive impact on students' learning and led to their mastery of research skills for global databases, regardless of their cognitive style. This may be because crowdsourcing patterns (competitive/collaborative) utilized students' skills and abilities whatever their cognitive style (focusing/scanning) and increased students' involvement in learning and mastering these research skills.

The researchers attributed the results of the seventh hypothesis to presenting educational tasks in the form of challenging problems, which attracted the attention of students in the collaborative crowdsourcing group. They were challenged to find solutions to these problems through the exchange and sharing of ideas and proposals. Positive participation in examining the content also increased their motivation, which helped in enabling students in the collaborative crowdsourcing group to acquire and develop scientific thinking skills. Students in the competitive crowdsourcing group implemented the required tasks without challenging their thinking as several stages and procedures were involved regarding scientific thinking. They were required to discuss and exchange opinions to refine them and formulate creative solutions to the problems.

These results are consistent with those of Parsons et al. (2017) who reported that crowdsourcing is a scientific research method that provides new, numerous, and unbiased data and can be used in conjunction with other approaches. It is similar to the descriptive survey method but differs in certain aspects. For instance, the survey asks specific questions about predetermined topics and statistical analyses are performed for quantitative research, while crowdsourced research allows for open questions and crowd discussions and is, therefore, a circular process.

The results for the eighth hypothesis indicated that students with a focusing style were superior in the post-application of the scientific thinking scale compared to students with a scanning cognitive style. These results are consistent with those of Al-Atoum (2010), Al-Jubouri (2010), and Qaoud (2016). This is because students with a focusing style have clear goals and exhibit high levels of attention and deliberation in responding to and solving problems and making decisions. This allows them to develop their scientific thinking skills. Students with a scanning style prioritize speed, view things superficially, and have a short attention span in terms of the duration of attention and the number of stimuli that are followed up, as a result of which their decisions are hasty and error-prone.

Finally, with regard to the ninth hypothesis, both styles of crowdsourcing (competitive/collaborative) had a positive impact on students' learning processes through crowdsourcing and led to students mastering scientific thinking skills regardless of their cognitive style.

It is important to mention that the future trends for crowdsourced e-learning environments are to provide high-quality solutions at lower costs; for example, by benefiting from the capabilities, abilities, and skills of all learners, and from the capabilities of the largest possible number of specialized human resources available on the internet. These capabilities and skills, and the acquisition of appropriate solutions to the problems that face learners, provide a valuable educational service. This is a service that will suit the needs of different learners, increase their involvement in the teaching and learning process, improve educational and technological products and services, enhance the satisfaction of learners and beneficiaries with the educational process, achieve competitiveness, and increase learners' demand for educational institutions.

Research Limitations

1. **Human limitations:** The study was restricted to postgraduate students at the Faculty of Specific Education, Alexandria University, excluding faculty members owing to the challenges associated with eliciting approval to extend the study to a larger audience.
2. **Objective limitations:** The global databases available within the Egyptian Knowledge Bank website.
3. **Spatial limitations:** Application using Microsoft Teams.
4. **Time limitations:** The first semester of the 2020/2021 academic year.

CONCLUSION

The current study evaluated the effect of the interaction between crowdsourcing style and cognitive style on the development of research and scientific thinking skills among postgraduate students by designing an e-learning environment. The results revealed a significant difference between crowdsourcing patterns (collaborative/competitive) in favor of the collaborative pattern. In addition, there was a significant difference between cognitive styles (focusing/scanning) in favor of students who adopted the focusing style. Furthermore, there was a significant effect on the interaction between crowdsourcing pattern (collaborative/competitive) and cognitive style (focusing/scanning) for each of the cognitive aspects of research skills in global databases through the e-learning environment based on the crowdsourcing pattern, the students' performance of those skills, and their scientific thinking.

In the light of these results, the following recommendations are made:

1- Utilizing the results of the current research in the design of e-learning environments based on crowdsourcing (competitive/collaborative) in general, and crowdsourcing collaboration in particular, because of their impact on the development of achievement, practical performance, and scientific thinking.

2- Employing crowdsourcing (competitive or collaborative) and benefiting from its educational benefits within learning strategies in electronic educational environments.

3- Developing research skills in global databases and scientific thinking among all postgraduate students in different colleges and universities.

In light of these results as well as those of previous studies, the following topics are recommended for further research:

1. Future research should address the same independent variables in the context of their interaction with other cognitive styles or other ways in which students are prepared to learn practical skills.
2. The current study focused on the performance and cognitive aspects of skills and practical thinking. Future research should address other dependent variables such as students' attitudes or satisfaction with the e-learning environment.
3. Future research should address the independent variables within the framework of other dependent variables such as critical thinking, innovative thinking, or student involvement in the learning environment.

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Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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