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E-training Environment for Developing Capstone Teaching Skills for STEM Teachers in Egypt

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Abstract

The research investigated the effectiveness of using an E-training environment in developing Capstone teaching skills among STEM teachers. To achieve the aim of the research, the researchers applied the one groups' quasi-experimental design and utilized three instruments as follows;1) list of the Capstone teaching skills; 2) Pre-Post achievement test developed by the researcher and implemented before and after applying the training content; 3) The observation card to observe acquiring the Capstone teaching skills determined by the researcher and they are two main fields of the needed skills, (EDP Field, and Process management field) comprising eight (8) main skills that are subdivided into sixty four (64) subskills required for the STEM teachers, after applying the training content through the E-training environment. The participants were chosen randomly (N=27) at Obour STEM School Cairo Governorate, Egypt. the researchers selected the quasi-experimental design in terms of the research population, the sample of the research, is one experimental group, and the methodology of the research. The researchers relied on pre-and post-testing procedures applied on the research group, the first test has been posted to the trainees after collecting

their responses on the training needs survey or a questionnaire that included 68 questions to identify their needs, the pre-test comprises 70 questions about the 64 sub-skill, then after that the training needs have been determined based on the pre-test results, through a month the training has been held Online on the Microsoft Teams as a main platform, by the end of the training sessions, the trainees have been asked to solve the post-test which is reapplied once again after another month .Therefore, the current research attempted to investigate the effectiveness of using the E-Training environment based on the SOLE technique as (the independent variable) in developing the Capstone teaching skills as (the dependent variable) among STEM teachers. Quantitative results showed that There is statistically significant difference at the level of (a<=0.05) between the pre-test and post-achievement test of the experimental group on developing Capstone teaching achievement of STEM teachers in favor of the post -test. And also, there is statistically significant difference at the level of (a<=0.05) between the pre-test and post- observation card of the experimental group on developing Capstone teaching skills of STEM teachers in favor of the post -test.
So, the researchers recommended employing the E-Training environment based on the SOLE technique in developing the Capstone teaching skills among STEM teachers in Egypt.

Keywords: E-training environment, Capstone (The Applied projects), Capstone teaching skills

1. Introduction:

Technology becomes an essential part of our lives and it is everywhere around us. Although it has a significant role in education in general, it is still not widely implied in our classrooms and the traditional methods dominate our educational system, if it is on the level of teaching in the classroom for the students or, on the level of training for the professional development for teachers. Towards the past decade the rapid development of computer and Internet technologies in the field of education has changed the ways of teaching, learning, as well as training. Digital education and e-learning applications offer easy access to knowledge domains and learning processes from everywhere for everybody at any time. Furthermore, information and computer technologies are considered some of the most beneficial teaching tools supporting student learning in the classroom (Lamb, R.L., Annetta, L., Firestone, J., Etopio,2018)

Many E-training environments and processes are based on participatory learning models in which participants share their understandings and aim to develop new insights into their workplace knowledge through discussion, questioning, mentoring and personal

reflection. Knowledge production is assumed to occur through the cumulative effect of these actions. However, equally likely outcomes include the sharing of ignorance or the development of erroneous understandings. Cognitive and social views of learning posit, however, that humans learn by thinking (not just by interacting), and that unless this is explicitly taken into account in developing training programs, optimal learning outcomes may not be achieved. This paper examines the importance of the E-training environments in order to maximize the potential for optimal learning to occur and provides STEM teachers with all tools that they need to develop their skills in teaching Capstone.

E-learning technologies have been diversified through the last decades, as there were many technologies has been evolved making great changes in our perception for learning and so our methodologies in teaching and training, that supported our students and trainees, from these technologies that the researcher will depend on in this study: -

1- E- training:

The term e-learning almost refers to the use of different kinds of information and communication technologies (ICT) and electronic devices in education. It is a broad term for teaching and educational activity that uses any electronic devices or network completely or only partially. E-learning is a change from the traditional education or training system to a more ICT-based personalized and flexible education systems. E-learning may also be referred to as distance learning, virtual education, digital education, web-based training (WBT), Internet based training (IBT), computer-based training (CBT) or technologically enhanced learning depending on the emphasis of the delivery method or the components. The delivered learning materials may be in the form of text, images, animations video tutorials or even a computer program. For example, in computer-based training a student learns by executing a special training program on a computer. Such training materials are usually embedded with the computer applications so the students can practice using the application as they learn. (Guragain, 2016).

2- The Self Organized Learning Environment (SOLE): -

A SOLE can be described as an environment which sparks curiosity to learn through the exploration of Big Questions using the Internet and people's organic drive to work together. In this environment, the teacher is a facilitator rather than transmitter of knowledge and therefore SOLE can also be described as a minimal intervention teaching approach. Sugata Mitra and his colleagues have carried out research for over 15 years on the nature of self-organized learning: how it works, to what extent, and the role of adults in encouraging it. His innovative and bold efforts towards advancing

learning for students all over the world earned him the first-ever $1-million-dollar TED Prize. At the 2013 TED conference, Mitra invited thinkers and doers worldwide to create their own SOLEs and share their discoveries via a School in the Cloud. (Jacquelyn O'Malley, 2017). Therefore, according to Mitra's study SOLE will give the STEM teachers the opportunity to deal freely with the technology in order to enhance their searching skills and free space to explore new experiences related to the topic under study in the Capstone course, which makes both the teacher and the student are in the same track. following to Mitra's study, the Self-Organized Learning Environment' refers to the adaptation of a school space to facilitate Enquiry Based Learning. A teacher encourages their class to work as a community to answer questions using computers with internet access. The class work around a guiding set of rules:

- Students need to form groups of about 4
- Children choose their own groups
- They can change groups at any time
- Children can look to see what other groups are doing and take that information back to their own group

They should be ready to present their answers back to the class at the end of the session (Mitra.S., others,2010), and through applying the Mitra's rules on the STEM teachers through their professional development will help them to communicate with their peers effectively, gaining new ideas or suggestions, expand their searching areas and while facing obstacles and overcoming it, they acquire eventually, the problem-solving skill. As, the self-organizing system is one where the system structure appears without explicit intervention from outside the system, also, it shows emergence the appearance of a property not previously observed as a functional characteristic of the system. education is a self-organizing system where learning is an emergent phenomenon. (OXFORGENGLAND, 2010)

1. Problem of the Research:

Capstone (the applied projects) teaching mainly aims to provide students with different skills as one of the most important 21st-century skills. Being one of the researchers is a Biology teacher & school general capstone leader, has noticed that teachers use the same traditional methods in their Capstone sessions that don't suit students' needs at all. Moreover, they are not aware of 21st century skills they must have firstly and develop those skills for the students to achieve all capstone process and fulfilling all stages of Engineering Design Process (EDP) effectively, although they are already trained on using the SOLE strategy in their professional development but, only in frame of terms not practicing the strategy - this is the second

observation for the researcher- being as a trainer, it has been noticed that the training not concerning to develop the needed skills for the teachers to be creative, have the ability to communicate correctly with the students and also, not providing them with the searching skills that are needed as well. Therefore, there is a real need to adopt new technologies that enhance and enrich the training experience of the STEM teachers. Studies found that, efforts should be particularly made in the increase of STEM teacher supply through a well-designed teacher professional development, which is a critical factor of a successful education (Jong 2019a, 2019b). Since STEM is a cross-disciplinary subject, it is expected that students are empowered to apply their disciplinary concepts and skills in integrated contexts (Kelley & Knowles, 2016; Tytler, Prain, & Hobbs, 2019). However, the majority of the current teachers who have received training in only one subject area may be unable to adopt an integrated and holistic approach to teach STEM (Aslam, Adefila, & Bagiya, 2018;). there is an obvious gap in research pertaining to teacher preparation and professional development (Al Salami et al. 2017; Cavlazoglu and Stuessy 2017). Teachers play a significant role in equipping students with relevant STEM knowledge and shaping their choice of STEM career. (Lee et al. (2015) longitudinal study employing logistic regression analyses of students' choice of a STEM career indicated that teachers' expectations of students are particularly influential. While the lack of focused study on teacher professional development to foster STEM learning warrants further investigation, the situation seems unsurprising. If it is already challenging for a teacher to master the pedagogical content knowledge. So, researchers have proven sort of weakness in developing Capstone teaching skills among STEM teachers through the trainings and the professional development of the STEM teachers In addition, the researchers also confirmed the existence of the problem through many sources as follows: First, due to the experience of one of the researchers' as a Biology HOD (Head of Department) at Obour STEM School and as a Biology teacher and a general Capstone leader in Obour STEM School, and also as a TOT in STEM system. It has been noticed through direct observation of the teachers during the Capstone sessions, meeting discussions, and trainings; by tracking teachers' progress from semester to another and by conducting individual and group interviews with STEM teachers to follow up on their work and identify problems that hinder their achievement in the Capstone sessions. Second, the researchers conducted a pilot study on a sample of (17) of STEM teachers for the academic year (2021/2022) using an electronic questionnaire divided into two sections: The first section contains (10 Multiple-choice questions) about the difficulties teachers encounter while Capstone training and the second section is for writing the teachers' comments and suggestions about how to improve the development of the Capstone teaching skills through the process

of the professional development. The researcher distributed the questionnaire through the Microsoft Team platform, and the results revealed that (70%) of the teachers were unable to develop the Capstone teaching skills and apply them in real life situations with their students in the Capstone sessions. And also from the second part of the questionnaire, it appeared that (80%) of the teachers are complaining from being travelling in the summer vacation from their countries in order to attend the Capstone training which is costly as well. Based on the above, the researcher suggested using an E-Training environment to emphasize its effectiveness in enhancing the teachers' Capstone teaching skills in STEM Schools by developing their Capstone teaching skills. Therefore, the research problem is represented in the lack of development of Capstone teaching skills among STEM teachers.

2. Questions of the Research:

The problem of the research tackled the following main question: "What is the effectiveness of E-training environment for developing Capstone teaching skills for STEM teachers in Egypt?"

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

3.1- What are the most important Capstone teaching skills for STEM teachers?

3.2- What is the perspective of an E-training environment content to develop Capstone teaching skills for STEM teachers?

3.3- What is the effect of using an E-training environment content to enhance the Capstone teaching skills of STEM teachers?

3.4- What is the effect of using an E-training environment content to enhance the performance aspects of STEM teachers?

4. Objectives of the Research:

The research aims to achieve the following objectives:

4.1- To identify the most important Capstone teaching skills for STEM teachers

4.2- To design an E-training environment content to develop Capstone teaching skills for STEM teachers.

4.3- To examine the effectiveness of using an E-training environment content to enhance the Capstone teaching skills of STEM teachers.

4.4- To examine the effectiveness of using an E-training environment content to enhance the performance aspects of STEM teachers.

5. Significance of the Research:

5.1- This research is an outcome of the recommendations of recent studies that consider the E- training environment is an innovative tool used for presenting good and effective training of STEM teachers through, the SOLE strategy which will help teachers to develop their Capstone teaching skills that is correlated to the 21st century skills like organizing information, thinking analytically, and creating new ideas, creativity, using technology in a high performance, communication , and being a problem solver.

5.2- This research aims to provide a suggested model of an E-training environment with an E-training content proceeded with an effective technique (SOLE) for preparing STEM teachers through the continuous professional development in order to be able to support their students in the capstone session, enabling them to integrate between what they have learned in STEM subjects and what they need to apply in their capstone project.

5.3- The importance of the target group also adds more significance to this study as A well-suited teacher professional development will not only equip teachers with sufficient STEM knowledge and related instruction approaches that can address the learning needs of students, but also develop their confidence in and positive perception of STEM education, which significantly correlates to the effectiveness of STEM learning.

5.4- It is a scientific attempt to overcome the low performance of the capstone teachers in their sessions and so the low performance of the students that may happen if the student needed skills have not been developed in the right way.

5.5- It is essential to make continuous professional development for STEM teachers to develop the capacity in designing and implementing STEM instructional practices However, nowadays it became very difficult due to the corona virus pandemic and its variants that threaten our daily work routine and are being dealt with through social distancing in all our life issues.

5.6- Therefore, this research aims to provide a suggested model of an E-training environment with an E-training content proceeded with an effective technique (SOLE) for preparing STEM teachers through the continuous professional development in order to be able to support their students in the capstone session, enabling them to integrate between what they have learned in

STEM subjects and what they need to apply in their capstone project.

5.7- Also, at the same time it offers a solution that ensures the ongoing teachers training through the unexpected conditions like recent pandemic corona virus crisis, and also appropriate for the teacher's distancing residency in order to make the process of the professional development is more sustainable.

6. Research Variables:

The research relied on the following variables:

6.1. Independent Variable:

An E-training environment

6.2. Dependent Variables:

Capstone teaching skills for the STEM teachers

7. Hypotheses of the Research

The research relied on the following hypotheses:

H.1 There is statistical significant difference at the level of (a<=0.05) between the pre-test and post- achievement test of the experimental group on developing Capstone teaching achievement of STEM teachers in favor of the post -test.

H.2 There is statistical significant difference at the level of (a<=0.05) between the pre-test and post- observation card of the experimental group on developing Capstone teaching skills of STEM teachers in favor of the post -test.

8. Method

8.1. Participants of the Research:

The research targeted the Capstone teachers in one of the Egypt STEM Schools, 27 of the STEM teachers, they are all working under the same administration, rules and work ambiance with different subject areas (Biology, Physics, Chemistry, Mechanics, Geology, Math, English, and Activities) Therefore, the researcher ensured that the target participants share these characteristics:

1. The teachers obtained similar results in their Pre-Test. So, they have approximately the same level of knowledge.
2. The teachers have approximately similar rules and work conditions.
3. Teachers have good computer and online communication skills and are proficient in the Microsoft Team platform.
4. They also prefer online learning and are interested in using various techniques in their learning process.

5. All teachers have not been exposed to a Capstone training experiences using the E-Training environment with the SOLE technique.

8.2. Research Design:

Descriptive approach was used in the current research to analyze literature related to the research variables, describe and build research tools, and discuss and interpret the results. The research employed a quasi-experimental method. The quantitative analysis of the data allowed the researcher to make comparison between the scores on pre-posttests. The research design involved one group of STEM teachers, has been trained through the E- training environment which is the main independent variable that has been applied on the experimental group. All key characteristics of a quasi-experiment were included in this study: (1) pre and post- achievement test to measure the cognitive aspect, and (2) pre and post Note card to measure the skill aspect (skills of 21st century) and (3) the assigned experimental group. Statistical analysis has been integrated in tables and figures throughout the research for providing a clearer and a more accurate reflection of the research findings.

8.3. Instrumentation:

The following instruments were designed and utilized by the researchers:

8.3.1. Data Collection Instrument:

The researchers conducted a pilot study on a sample of (17) of STEM teachers for the academic year (2021/2022) using an electronic questionnaire divided into two sections: The first section contains (10 Multiple-choice questions) about the difficulties teachers encounter while Capstone training and the second section is for writing the teachers' comments and suggestions about how to improve the development of the Capstone teaching skills through the process of the professional development. The researchers used Microsoft Forms to write the questionnaire and the Microsoft Team platform to send it.

8.3.2. Measuring Instruments:

1. Survey of the training needs, to determine the Capstone teaching skills that are needed by the trainees, and the degree of need for each one of the main skills and also each one of the sub-skills. The survey is formed of (8) main skills, and (64) sub-skills. After conducting the survey and collecting the responses, the percentage of skill needs ranged from 90.12% to 98.77%. This was taken into consideration

when designing the activities, with a focus on addressing the skills that are in higher demand.

2. Pre-post achievement Test, that is formed of (70) questions, the pre-achievement test has been sent to the trainees before introducing the training content, then it was resent again after finishing the training content.

   The researchers calculated the validity of the test's internal consistency by calculating the correlation coefficients between the STEM teacher' scores on each of the test items on a random sample of (10) STEM teachers from outside the study sample and within the community. The correlation coefficient for the items ranged between (0.730 - 0.854) and reached the overall internal consistency correlation coefficient (0.811), which indicates that there is internal consistency for the test questions and for the overall test, and thus the internal consistency of the test questions was confirmed.

3. Capstone teaching skills observation card, that is formed of list contained of (8) main skills and (64) subskills, distributed over two main areas which are: The EDP field, & The Management field

   The researchers calculated the reliability of the observation card and made sure that it would give similar results if it was reused again, as the researcher observed (5) trainees from the piloting sample, as well as enlisted the help of other trainers to observe the performance of the trainees, and after monitoring the quantitative estimates of the performance of the trainees in the observation card, The researcher calculated the extent of agreement and disagreement between the researcher (the first observer) and the assistant (the second observer) using Cooper's equation, which states:

The percentage of agreement = (the number of times of agreement / (the number of times of agreement + the number of times of disagreement)) x 100.

After applying the equation to the quantitative estimates of the trainees' performance in the observation card, the researcher found an agreement rate (89.06%) for the total skills of the observation card.

8.3.3. Treatment Instrument

The researchers selected the Microsoft Team platform for building the E-Training environment because of several factors listed below:

1. Microsoft Team is the official platform used by the Ministry Of Education (MOE).
2. All teachers have their own Microsoft Team accounts and can easily access their Capstone channels and interact with their Capstone training content.

3. Teachers use Microsoft Team platform daily in their teaching process and making online meetings with their students. Therefore, the researcher explored the benefits of using Teams as an E-Training environment for delivering the training content through the Capstone channel.
4. Microsoft Team platform can help equip teachers with 21st-century skills like critical thinking skills, communication skills, and problem -solving skills in particular, by using all Microsoft Teams tools with their Capstone training content.
5. Microsoft Teams platform assists with classroom management and monitoring of the teachers' collaboration and works in real-time sessions.
6. Microsoft Teams platform tracks the teachers' progress and facilitates the development of Capstone concepts and skills included in their training content.
7. Microsoft Teams is accessed on any browser or device. Moreover, the researcher designed the E-Training content in a form of PowerPoints, PDFs, and group of activities and assignments (questions/ answers) design to measure all levels of Bloom's taxonomy and enhance higher-order thinking by using images, text, animation, and videos. As a result, the training content could foster the development of Capstone concepts and skills included in the different Capstone projects since starting STEM education project in Egypt.

In this phase several critical steps were undertaken to create an effective electronic professional development platform. Initially, electronic tools were meticulously crafted to support the training process. This involved the identification of key tools essential for designing the training content, enabling a seamless educational experience. Subsequently, the focal activities within the training content were systematically built, ensuring alignment with the overarching objectives. The production phase also encompassed the development of interactive elements, enhancing engagement and knowledge retention. Furthermore, content was tailored to encourage active participation among trainees, as well as facilitate dynamic interaction between peers and trainers.

8.4. Delimitation of the Research:

- This research has been applied on (27) Capstone teachers from one of the Egypt STEM Schools, during the 2nd semester of the scholastic year 2022-2023 to develop the Capstone teaching skills through designing an academic portal platform (Microsoft Teams) for sharing and delivering the training content materials

and applying all needed activities included in the E-training program.

- This research has been applied only for developing the Capstone teaching skills which are correlated to the 21st century skills for STEM teachers

8.5. Data Analysis:

The researchers verified the research hypotheses through the statistical analysis of the collected data that was applied using the Statistical Package for Social Sciences (SPSS) Version (21). The researcher analyzed and calculated data by applying the following statistical styles:

1. There is statistical significant difference at the level of (a<=0.05) between the pre-test and post- achievement test of the experimental group on developing Capstone teaching achievement of STEM teachers in favor of the post -test.
2. There is statistically significant difference at the level of (a<=0.05) between the pre-test and post- observation card of the experimental group on developing Capstone teaching skills of STEM teachers in favor of the post -test.

1. Theoretical Framework:

E-training, synonymous with online learning, employs digital technologies to facilitate remote educational content delivery, fostering collaboration and interactivity among learners. Its objectives span enhancing knowledge acquisition, skills development, critical thinking, motivation, accessibility, and cost-effectiveness, supporting continuous professional development and fostering collaboration. Moreover, e-training is pivotal for compliance training, measuring learning outcomes, and fostering self-directed learning.

The concept of e-training, or electronic training, has emerged as a transformative approach to delivering educational content and facilitating learning experiences through digital platforms.

E-training draws upon established theories such as constructivism, connectivism, and engagement theory to inform the design and delivery of effective learning experiences in digital environments, emphasizing active participation, collaboration, and knowledge construction among learners. (Clark, & Mayer, 2016).

E-training, synonymous with e-training, involves the delivery of educational content and instructional materials via the internet or digital platforms. It enables learners to access training resources remotely, often through web-based applications, learning management systems (LMS), or virtual classrooms, allowing for flexible and self-paced learning experiences (Mesidor & Anderson, 2022).

The study of Alizadeh et al (2021) discussed e-training and its impact on the training environment. It mentions that online training can provide efficiencies and advantages, but adjustments may be needed by adopting organizations, It offers the flexibility for learners to proceed at their own pace and engage in self-directed learning, while also providing opportunities for interaction with trainers and other learners through online platforms.

E-training environments encompass various digital platforms and settings where electronic training activities take place. These environments facilitate the delivery of educational content and interactive learning experiences.

- *Learning Management Systems (LMS)***:** LMS platforms provide centralized hubs for organizing, delivering, and tracking e-training activities. They offer features such as course creation, content management, assessment tools, and learner analytics, enabling efficient management of training programs in corporate, academic, and organizational settings (Norberg et al., 2011).
- *Virtual Classrooms***:** Virtual classroom environments simulate traditional classroom settings using web conferencing tools and real-time communication technologies. They facilitate interactive lectures, discussions, group activities, and live demonstrations, allowing remote learners to engage in synchronous e-training sessions (Abrami et al., 2008).
- *Mobile Learning (M-Learning) Platforms*: M-learning platforms deliver e-training content and activities through mobile devices such as smartphones and tablets. These platforms leverage mobile apps, responsive websites, and multimedia resources to provide on-the-go access to training materials, enabling learners to engage in self-paced learning anytime, anywhere (Kukulska-Hulme & Traxler, 2007).
- *Social Learning Platforms***:** Social learning platforms integrate social networking features with e-training content, fostering collaboration, knowledge sharing, and community building among learners. These platforms facilitate peer interaction, mentorship, and informal learning experiences through discussion forums, blogs, wikis, and multimedia sharing (Dabbagh & Kitsantas, 2012).

An E-training environment refers to a digital platform or system that is used for delivering educational or training content to learners over the internet, It provides a virtual space where learners can access learning materials, participate in interactive activities, and engage in collaborative learning experiences (Cheng et al., 2023).

These environments can support different types of training, including language training, technical training, and professional development, They enable learners to study at their own pace, access a wide range of resources, and receive guidance and feedback from instructors , and can be particularly beneficial in situations where physical classroom attendance is not possible, such as during pandemics or for remote learners, and provide flexibility and convenience, allowing learners to access educational content anytime and anywhere with an internet connection (Kim et al., 2023).

From the previous, the researchers concluded that E-training environments like Microsoft Teams have emerged as integral tools in modern education, offering a versatile platform for online learning (Microsoft, 2024). With features tailored for educational purposes, such as virtual classrooms, document sharing, and real-time collaboration, Microsoft Teams facilitates interactive and engaging learning experiences (Microsoft, 2024). The platform's integration with Microsoft Office suite enhances productivity and enables seamless content creation and sharing (Microsoft, 2024). Furthermore, the chat and video conferencing functionalities allow for synchronous communication, enabling educators to provide immediate feedback and support to students (Microsoft, 2024). As a result, Microsoft Teams empowers educators to create dynamic and interactive virtual learning environments that cater to diverse learning needs (Microsoft, 2024).

A set of theories explains how learners are trained, how knowledge is introduced, and how that knowledge is processed within the learner's mind. For e-training environments to be purposeful and effective, they must be based on an underlying approach. Future progress in e-learning will come from a better understanding of training mechanisms, not just from technological improvements or their utilization (Abu Khatwa, 2010):

A capstone project is a multifaceted assignment that serves as a culminating academic and intellectual experience for students, typically at the end of their academic program. It often involves research, critical analysis, problem-solving, and synthesis of knowledge and skills acquired throughout the course of study. .

Learning Theories

Constructivist theory defines learning as the process of adaptation resulting from the learner's functional cognitive systems, whereby they construct their knowledge based on their previous experiences. Its function lies in adapting to organize their perceived world (Yu & Tao, 2007, p. 71).

Activity Learning Theory: Focuses on group collaboration and the Zone of Proximal Development (ZPD), where learners progress with guidance. It emphasizes real-world activities and continuous interaction as mentioned by Shafer and Moss (2010)..

Social Learning Theory: Proposes that individuals learn through observation, imitation, and modeling of others' behaviors. Vicarious learning and self-efficacy play crucial roles (Bandura, 1977).

Cognitive Theory: Focuses on knowledge construction and the relationship between perception and reality. It highlights the importance of memory and organizing knowledge (Mayer, 2014). Moreover, Sweller (2010) stated that cognitive learning involves gathering and organizing knowledge.

Behaviorism Theory: Concentrates on observable behaviors learned through conditioning, reinforcement, feedback, and repetition. It also emphasizes social learning and gamification.

Capstone teaching skills

Capstone projects are pivotal in higher education, offering students a comprehensive academic experience by integrating research, critical analysis, problem-solving, and the synthesis of knowledge. These projects, occurring typically at the end of an academic program, take various forms such as research papers, case studies, or presentations, aiming to address real-world challenges relevant to the student's field of study. Interdisciplinary in nature, they require students to draw upon knowledge from multiple disciplines, collaborate with faculty or industry experts, and present their findings

Kahn & Dell'Olio (2019) define capstone experiences as culminating, integrative experiences in which students synthesize and apply what they have learned in the major.

STEM education refers to an interdisciplinary approach to teaching and learning that integrates concepts and principles from science, technology, engineering, and mathematics. The aim of STEM education is to prepare students for success in the rapidly evolving fields of science, technology, engineering, and mathematics by fostering critical thinking, problem-solving skills, creativity, and collaboration.

Capstone projects in education represent the culmination of students' academic experiences. They typically occur towards the end of a degree program and integrate learning from various courses and subjects. According to the National Association of Colleges and Employers (NACE), capstone projects allow students to demonstrate the application of knowledge and skills learned throughout their academic experiences (National Association of Colleges and Employers, 2024).

As described by the University of North Carolina at Chapel Hill, capstone projects involve in-depth research and critical thinking to address complex issues (UNC-Chapel Hill, 2023).

According to the University of Washington, capstone projects allow students to demonstrate their competencies and readiness for further academic or professional endeavors (University of Washington, 2020).

Challenges of Teaching Capstone:

According to O'Reilly and McMahon (2008), accommodating diverse student backgrounds and abilities is a significant challenge in capstone courses, as instructors must balance providing support for struggling students while challenging more advanced learners.

Capstone projects typically involve complex, open-ended problems that may not have clear-cut solutions. And guiding students while allowing them to explore the needed knowledge may be challenging for the instructors. As noted by Prince et al. (2007), designing meaningful capstone projects that balance structure and flexibility is essential for ensuring student engagement and learning. According to Strang (2012), securing sufficient resources and support for capstone projects remains a significant challenge for many educational institutions.

Developing valid and reliable assessment methods that capture the breadth of student learning is a challenge for instructors. As highlighted by Rhoads (2017), assessing the multifaceted outcomes of capstone projects requires

Managing time effectively to ensure that students make progress on their projects while covering essential content and meeting course objectives can be challenging. According to Johnson et al. (2005), time management is a common challenge faced by instructors teaching capstone courses, as they must balance project work with other course requirements.

So that, teaching capstone projects presents challenges related to managing diverse student backgrounds, guiding students through complex projects, providing adequate resources and support, assessing multifaceted outcomes, and managing time effectively. Addressing these challenges requires careful planning, collaboration, and ongoing reflection to ensure the success of capstone experiences for both students and instructors

Capstone teaching skills encompass a diverse set of competencies essential for guiding students through the capstone project process effectively. These skills include but are not limited to research, decision-making, communication, time management, and critical analysis. Research skills are foundational, enabling students to engage in scholarly inquiry, gather relevant information, and contribute to knowledge advancement (Swanson et al., 2015). Decision-making skills are crucial for navigating complex problems, evaluating alternatives, and selecting the most appropriate course of action, which is essential for successful project outcomes (Kwon & Kim, 2014). Effective communication skills facilitate the

dissemination of ideas, findings, and recommendations, fostering collaboration and knowledge sharing among project stakeholders (Wang et al., 2019).

Furthermore, time management skills are essential for students to plan, organize, and prioritize tasks effectively, ensuring the timely completion of project milestones and deliverables (Seiferth et al., 2017). Critical analysis skills enable students to evaluate data, information, and findings critically, drawing meaningful conclusions and actionable insights from their research (Brown & Rutherford, 2016). These skills collectively contribute to the successful execution of capstone projects, preparing students for academic and professional success beyond the classroom.

STEM concept:

STEM education, encompassing science, technology, engineering, and mathematics, serves as the cornerstone of modern societies, driving innovation and economic growth. Stemming from the need to cultivate a skilled workforce capable of tackling complex challenges, STEM education integrates multidisciplinary curricula across all grade levels. By nurturing skills such as critical thinking, problem-solving, and collaboration, STEM education prepares students for success in diverse fields and fosters informed citizenship in an increasingly technological world.

This is due to the fact that STEM students have the ability to identify, apply, and integrate concepts from science, technology, engineering, and mathematics to understand complex problems and innovate to solve them. (Meng, Idris & Eu, 2014: 219-220).

Gonzalez & Kuenzi (2012) pointed out that education gained through the STEM system, which includes multidisciplinary curricula in the fields of science, technology, engineering, and mathematics, holds global importance through its innovative educational approaches.

STEM education is a multidisciplinary approach that contributes to the development of workforce skills in the twenty-first century, higher-order thinking skills, and the development of nations (Erdogan et al., 2017: 614).

The National Science Foundation (NSF) introduced the idea of STEM in the late 1990s in the United States. Originally, the acronym was SMET, but after various studies, it evolved into STEM (Williams & Larwin, 2016). The word S.T.E.M. is an acronym for science, technology, engineering, and mathematics. Many researchers may use this acronym to define education for science, technology, engineering, and mathematics. STEM is defined by the separate subjects that constitute it (Bybee, 2010). Education for science, technology, engineering, and mathematics should be defined as an integrated curriculum and education. This is excellently

achieved by removing any boundaries between subjects and treating them as one subject (Morrison, 2006).

The methodology of STEM education emphasizes hands-on learning, inquiry-based approaches, and interdisciplinary problem-solving. Through collaborative projects and real-world challenges, students gain practical experience and develop a deeper understanding of STEM concepts. Integration of technology further enhances learning opportunities, while ongoing assessment and reflection support continuous improvement

By engaging in practical activities such as experiments, projects, and real-world problem-solving tasks, students not only deepen their understanding of STEM subjects but also develop essential skills like collaboration and communication (Honey et al., 2014)..

The objectives of STEM education are multifaceted, aiming to promote innovation, continuous curriculum renewal, and the enhancement of core skills for the twenty-first century. Additionally, STEM education seeks to prepare students for STEM careers, address global challenges, and promote equity and inclusion in education.

STEM teachers play a pivotal role in facilitating inquiry-based learning, integrating technology, promoting collaboration, fostering creativity, and addressing diversity and equity. Moreover, they collaborate with colleagues, industry partners, and community stakeholders to enhance STEM education initiatives and create diverse learning opportunities for all students (National Science Board, 2015). Through their dedication and innovative teaching methods, STEM teachers inspire the next generation of scientists, engineers, and innovators, driving forward progress and innovation in society (Bybee, 2013; Johnson et al., 2018).In Egyptian schools, STEM teachers face challenges such as limited resources and outdated curricula but remain committed to preparing students for the demands of a rapidly evolving world and driving technological advancement and economic development. Despite these challenges, dedicated STEM teachers in Egypt are working tirelessly to inspire and empower their students to pursue careers in STEM fields, driving the nation's progress towards a knowledge-based economy (El-Zeftawy & El Kordy, 2020)..

In conclusion, STEM education and the dedicated efforts of STEM teachers are essential for equipping students with the skills and knowledge needed to thrive in an increasingly complex and interconnected world. Through innovative teaching methods and a commitment to excellence, STEM education empowers the next generation of leaders, innovators, and problem-solvers.

10. Findings and Discussions:

The researchers utilized two instruments (the achievement test and the observation card test) to test the researchers' hypotheses. The following results were obtained and analyzed using SPSS statistical software version (21) as follows:

H.1. There is statistical significant difference at the level of (a<=0.05) between the pre-test and post- achievement test of the experimental group on developing Capstone teaching achievement of STEM teachers in favor of the post -test. . To validate the first research hypothesis, a paired Sample t-test was used as shown in the following table.

N=27

Skill	Application	Mean	Std. Deviation	Earning		t	df	Sig.	$\square^2$
				Mean	Std. Deviation				
Capstone teaching skills Achievement	Pre	34.67	3.174	23.407	3.029	40.157	26	0.000	0.984
	Post	58.07	2.319						

Table (1) Results of paired sample t-test to verify of differences between mean scores of Capstone teaching skills achievement test in pre and post application

Notes from the table above that mean scores of "Capstone teaching skills Achievement" achievement in pre application reached (34.67) with a standard deviation of (3.174), while the mean score was reached in post application (58.07) with a standard deviation of (2.319), the earned mean score in Capstone teaching skills Achievement was (23.407) with a standard deviation (3.029), the value of t-test between the two mean scores was (40.157), this value has a significance at the level of (0.05), as the calculated significance is equal to (0.000) which is less than (0.05), also the Impact factor has been extracted using Eta^2 via t value resulting from the mean difference in Capstone teaching skills Achievement test for STEM teachers in pre and post test, Where it turns out that Eta^2 value was (0.984) which indicated that the impact of E-training environment moderately achieved to develop Capstone teaching skills Achievement for STEM teachers, which means accepting the first research hypothesis

2. There is statistically significant difference at the level of (a<=0.05) between the pre-test and post- observation card of the experimental group on developing Capstone teaching skills of STEM teachers in favor of the post -test

To verify the validity of the Second research hypothesis that states: " There is statistically significant difference at the level of (a<=0.05) between the pre-test and post- observation card of the experimental group on

developing Capstone teaching skills of STEM teachers in favor of the post - test.", A Paired Sample t-test used as shown in the following table.

Skill	Application	Mean	Std. Deviation	Earning		t	df	Sig.	□ 2
				Mean	Std. Deviation				
The research skills	Pre	15.93	1.859	13.963	2.609	27.810	26	.000	0.967
	post	29.89	1.805						
The decision-making skill	Pre	13.44	3.250	11.259	3.265	17.918	26	.000	0.925
	post	24.70	1.031						
The designing skills	Pre	10.44	1.219	7.630	2.420	16.381	26	.000	0.912
	post	18.07	1.752						
The Analyzing skills	Pre	15.81	2.001	12.852	3.613	18.483	26	.000	0.929
	post	28.67	2.646						
Communication skills	Pre	13.93	1.730	15.370	2.976	26.835	26	.000	0.965
	post	29.30	2.091						
Time management skill	Pre	3.96	.706	3.926	1.141	17.878	26	.000	0.925
	post	7.89	.847						
Risk management	Pre	7.11	.801	6.778	1.368	25.742	26	.000	0.962
	post	13.89	1.050						
Budgeting	Pre	6.48	1.282	3.963	1.581	13.027	26	.000	0.867
	post	10.44	.892						
All Capstone teaching skills	Pre	87.65	5.010	75.296	6.330	61.814	26	.000	0.993
	post	162.85	3.581						

Table (2) Results of paired sample t-test to verify of differences between mean scores of Capstone teaching skills observation card in pre and post application

The mean scores of “All Capstone teaching skills” observation card in pre application reached (87.65) with a standard deviation of (5.010), while the mean score was reached in post application (162.85) with a standard deviation of (3.581), the earned mean score in The All Capstone teaching skills was (75.296) with a standard deviation (6.330), the value of t-test between the two mean scores was (61.814), this value has a significance at the level of (0.05), as the calculated significance is equal to (0.000) which is less than (0.05), also the Impact factor has been extracted using Eta2 via t value resulting from the mean difference in The All Capstone teaching skills observation card for STEM teachers in pre and post test, Where it turns out that Eta2 value was (0.993) which indicated that the impact of E-training environment moderately achieved to develop Capstone teaching skills for STEM teachers, which means accepting the second research hypothesis

Discussion

The research examines the effect of the independent variable (an E-training environment) on the dependent variables (the Capstone teaching skills). The obtained results revealed the high effectiveness of using the E-training environments in developing the Capstone teaching skills. Therefore, the current research led to the following findings:

A. The proposed-training environment has proven its effectiveness in developing the Capstone teaching skills for the STEM teachers in STEM Schools.

B. The participants had positive feedback and comments as they felt comfortable and motivated to interact with the E-training content in a supportive and free-judgment atmosphere. Therefore, they could develop their Capstone teaching skills that were aroused from the training activities (related to the past Capstone projects).

Conclusion

Based on the research findings, the researcher confirms the effectiveness of using the E-Training environment in developing the Capstone teaching skills for the STEM teachers. The E-training environment engaged and immersed the teachers in their training process at their own pace and provided more practice for knowledge retention. In conclusion, using E-training environment in the Capstone training has improved teachers' achievement and performance. Moreover, reviewing the above results and relevant literature enabled the researcher to confirm the high effectiveness of using the E-training environment in developing Capstone teaching skills of STEM teachers as follows:

1. Flexibility and Accessibility: E-training allows teachers to access training materials and sessions from anywhere with an internet connection. This flexibility is especially valuable for educators who may have busy schedules or live in remote areas.
2. Cost-Efficiency: E-training often eliminates the need for travel and accommodation expenses associated with in-person training. It can also reduce the cost of printing training materials, as digital resources can be easily shared and accessed.
3. Scalability: E-training can accommodate a large number of participants simultaneously, making it suitable for training programs involving numerous teachers or even educators from different locations. This scalability is not always possible with traditional in-person training.
4. Interactive Learning: Platforms like Microsoft Teams offer features for interactive learning, such as live chats, discussions, and virtual

classrooms. Teachers can engage in discussions, ask questions, and collaborate with trainers and peers in real time.

5. Resource Sharing: E-training environments make it easy to share a wide range of resources, including documents, presentations, videos, and links to relevant websites. Teachers can access these materials both during and after the training sessions.
6. Scheduling Flexibility: Teachers can choose training sessions that fit their schedules, and recorded sessions can be accessed later for review. This asynchronous learning approach accommodates varying time constraints.
7. Assessment and Feedback: E-training platforms often include tools for quizzes, assessments, and surveys. Trainers can gauge participants' understanding and gather feedback for continuous improvement.
8. Professional Development Tracking: E-training platforms can track teachers' progress and completion of training modules, making it easier to monitor professional development and compliance with training requirements.
9. Customization: Training programs can be tailored to individual needs and levels. Teachers can focus on areas where they need improvement and progress at their own pace.
10. Reduced Environmental Impact: E-training is more environmentally friendly, as it reduces the need for printed materials and minimizes carbon emissions associated with travel.
11. Integration with Other Tools: Platforms like Microsoft Teams often integrate with other educational tools and applications, enhancing the overall training experience.
12. Safety and Health: During public health crises like the COVID-19 pandemic, E-training allows for safe and socially distanced learning, reducing health risks associated with in-person gatherings.
13. Global Collaboration: E-training environments enable educators to connect with peers and experts from around the world, fostering global collaboration and the exchange of innovative teaching practices. E-training environments often integrate collaborative tools such as shared documents, virtual whiteboards, and video conferencing. These tools facilitate real-time collaboration on projects and initiatives, regardless of participants' locations.

In summary, utilizing an E-training environment like Microsoft Teams can significantly enhance teacher training by offering flexibility, accessibility, cost-efficiency, and a range of interactive and collaborative features. It aligns with the modern approach to education and professional

development, ensuring that teachers have access to the resources and the support they need to excel in their roles.

The current research results are consistent with the previous studies providing clear evidence for the effectiveness of using E-training environment in developing the Capstone teaching skills. However, the current research added more depth than previous studies in the points outlined below:

E-training environments facilitate global collaboration and the connection with peers and experts from around the world in several ways:

1. Online Communities and Forums: E-training platforms often host discussion forums or communities where participants can interact with peers. These communities can include teachers, trainers, and experts from diverse geographical locations. Participants can share experiences, seek advice, and engage in discussions on various educational topics.
2. Virtual Conferences and Webinars: E-training platforms can host virtual conferences and webinars featuring speakers and experts from different parts of the world. These events allow educators to attend presentations, workshops, and panel discussions without the need for physical travel.
3. Collaborative Projects: E-training environments enable the creation of collaborative projects that involve educators from different countries. Participants can work together on research, curriculum development, or other educational initiatives, leveraging their collective expertise.
4. Guest Lectures and Expert Sessions: E-training environments make it easy to invite guest speakers and experts from various countries to conduct lectures or training sessions. This exposes participants to diverse perspectives and expertise. We can utilize this advantage through making the meetings of the preliminary reviews in order too evaluate the students' ideas scientifically before starting building their prototypes, or holding meetings with professors from the university to reduce the number of field trips.
5. Peer Review and Feedback: E-training platforms often support peer review processes for assignments and projects. Teachers from different countries can provide feedback on each other's work, offering valuable insights and suggestions.
6. Cross-Cultural Learning: Participants in e-training programs have the opportunity to learn about different cultures, teaching methods, and educational systems. This cross-cultural exposure can enrich their understanding and pedagogical approaches.

7. Online Networking: E-training platforms typically include features for networking. Participants can create profiles, connect with others, and build professional relationships with educators from around the world.
8. Language Support: Language translation features within e-training platforms can help overcome language barriers, enabling educators from different linguistic backgrounds to communicate and collaborate effectively.

In summary, e-training environments leverage technology to break down geographical barriers, allowing educators to connect and collaborate with peers and experts from diverse locations. This global collaboration fosters the exchange of knowledge, best practices, and innovative ideas in the field of education, ultimately benefiting teachers and students worldwide.

Pedagogical Implications:

Using Microsoft Teams as an e-training environment for improving the Capstone teaching skills of STEM (Science, Technology, Engineering, and Mathematics) teachers has several pedagogical implications as follows:

1. Blended Learning: Microsoft Teams allows for a blend of synchronous and asynchronous learning, accommodating different learning styles and schedules.
2. Group Projects: Teachers can collaborate on capstone project development, sharing ideas, best practices, and feedback within the Teams environment.
3. One-on-One Coaching: Teachers can schedule one-on-one coaching sessions with trainers or experts through Teams, allowing for personalized support.
4. Assignment Submission: Teachers can submit capstone project drafts for feedback through Teams. This process supports formative assessment and iterative improvement.
5. Peer Review: Teams can facilitate peer review of capstone projects, fostering a culture of constructive feedback and improvement.
6. Resource Repository: Teams can serve as a repository for educational materials, research papers, and relevant content, making it easy for teachers to access and share resources.
7. Professional Development: Certifications and Badges: Teachers can pursue Microsoft certifications and earn badges through training modules within Teams, enhancing their professional qualifications.
8. Progress Tracking: Teachers and administrators can monitor progress through analytics and reporting features in Teams, identifying areas where additional support is needed.

9. Technical Support: Teams offers technical support resources to troubleshoot any platform-related issues, ensuring a smooth learning experience.
10. Data-Driven Decision-Making through Data Analytics: Teams provides data analytics tools to assess teacher engagement and performance, enabling data-driven decisions to improve the training program continually.
11. Professional Learning Communities: Teachers can join Teams-based professional learning communities focused on specific STEM disciplines or capstone project themes, fostering collaboration and knowledge sharing.
12. Feedback Loops: Continuous Improvement: Regular feedback mechanisms within Teams allow for ongoing refinement of training content and delivery methods based on teacher input.

Incorporating Microsoft Teams as an e-training environment for capstone teaching skills enhances pedagogical practices by promoting flexibility, collaboration, access to experts, effective assessment, and continuous improvement. These pedagogical implications contribute to the professional growth and effectiveness of STEM teachers involved in capstone education.

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