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RESEARCH ARTICLE

DESIGN AND VALIDATION OF EDUCATIONAL THEORIES-BASED FRAMEWORK FOR E-LEARNING SYSTEMS

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Abstract

Educational theories play a key role in attaining e-learning success. This contribution of theories is even more important for primary education which requires special attention since children possess childish behaviors.However, research shows that most e-learning systems lack theoretical foundations. We argue that these systems can be more effectively utilized by integrating educational theories. Therefore, we offer an e-learning system design framework based on learning and e-learning theories for primary education. The paper first discusses educational theories from different domains. Next, we provide an overview of how each theory can contribute toa successful e-learning system. Ethnographic Content Analysis (ECA) was conductedof the most renowned theories to construct this framework. Shortlisted theories belonged to domains of constructivism, early education, and e-learning. Design principles from each theory were extracted with the help of grounded theory methodology. These principles were mapped to e-learning system components including tasks, tools, and interfaces by performing thematic analysis.A comprehensive framework based on theoretical design principles was constructed. Lastly, the framework was validated by developing an e-learning system based on design principles. We evaluated students' academic performance after they used the developed system for three weeks. Findings revealed that an e-learning system has great potential in primary education and can assist practitioners in achieving desired learning outcomes by integrating educational theories. It was also found that the sequence in which learning activities are performed can overshadow a system's performance and hence needs to be addressed for e-learning success.

Introduction:-

The usefulness of e-learning urges us to focus more on exploring enhancement techniques of e-learning systems at all education levels. Among these levels, primary education is a special case where children are too young to cater to their learning needs on their own. In consideration of these factors, various forms of e-learning are explored for primary education. Although numerous systems are available, there isa lack of e-learning systems for primary education. Moreover, most of the research focus is on technical aspects of e-learning systems and less attention is paid topedagogical attributes [1]. Also, the current e-learning infrastructure follows a one-size fit all learning

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framework where similar learning resources are provided to all students [2]. Consequently, students with learning difficultiesinthe subjects have a higher failure percentage [2]. This urges to pay more attention toprimary education because the learning needs of children are different from those of adults [3].

On the other side, educational theories are deemed as an essential ingredient of successful learning with broad coverage of teaching and learning techniques and methods. Hence, there is a dire need to utilize educational theories for successful e-learning systems for primary education. Also, e-learning systems must be developed in accordance withlearning theories [4] as theories set up the pedagogical foundation of e-learning [5].

Despite the practicality of theories, still there is a lack of conceptual and theoretical frameworks ([6], [7]). It is also evident that in most cases, e-learning systems are developed without having an insight intotransforming learning theories into educational requirements [8]. Consequently, there is no guarantee of successful achievement of learning outcomes by only depending on a technology-based approach [9]. Therefore, there is a need to link theory with practice [10] because learning practice cannot develop fully without theory [11].For this purpose, this study aims to provide a comprehensive framework based on educational theories for successful e-learning systems in the context of primary education. It is pertinent to mention here that three essential components of an e-learning system are tasks, tools, and interface [12]. Tasks include performing learning tasks with the help of a system, tools component describes those tools which are vital to carry out different learning tasks, and the interface is that medium that is used by learners in order to interact with learning tools to accomplish tasks [12].In order to have a comprehensive design framework for successful e-learning systems for primary education, both domains i.e., educational theories and e-learning system componentsseek attention.However, as mentioned earlier, it is evident that an e-learning system's performance is affected by the sequence in which learning activities are conducted. Therefore, in this study, we aim to validate the proposed framework by exploring the interaction patterns of primary students in the context of the sequence of learning activities using Python 3. Hence, we attempt to address the following research questions with the help of this study:

RQ-1: How to develop a comprehensive design framework for e-learning systems by utilizing educational theories in primary education?
RQ-2: How to validate the framework by exploring students' learning patterns?

Framework Development Process (RQ-1)
This section explains the complete procedure of how we addressed our first research question.

Selection Of Educational Theories
We performed ECA in order to find the most relevant educational theories from an e-learning and primary education perspective. It was found that e-learning systems should adopt a learner-centered approach [13]. Constructivist learning theories provide the basis for learner-centered approaches [14] and are proven to be a good fit for e-learning [15]. According to Baah-Duodu et al. [4], the constructivism domain is deep-rooted into the learning theories of Dewey [16], Piaget [17], Vygotsky [18] and Bruner [19]. Therefore, we considered these four constructivist theories for framework development.

Early education theories are evidently significant from a primary education perspective. Among these, theories of Montessori, Waldorf education, and Reggio Emilia are considered the best-known approaches [20] due to their existence as strong educational alternatives and progressive nature [21]. However, Waldorf education discourages computer utilization in classrooms for children 13 years and less [35] to promote the healthy development of child imagination ([22], [36]). Consequently, we included the Montessori method [21] and Reggio Emilia [23] approach.

However, research shows that there is no single learning theory for e-learning in general [24] and also learning theories are not adequate for the implementation of e-learning systems [8]. Therefore, we aim to minimize this gap by adopting e-learning theories as these are established to support technology-oriented learning. Numerous such theories are available, but we included only those e-learning theories which are relevant to primary education, applicable in formal education (i.e., classroom settings) and are described in the English language. So, we were left with anchored instruction [25], constructionism [26], e-learning theory [27], game reward system [28] and gamification [29]. Table 1 summarizes our collected educational theories.

Table 1:- Selected Theories.

Domain	Selected Theories
Constructivism	Dewey [16]
	Piaget [17]
	Vygotsky [18]
	Bruner [19]
Early Education	Montessori [21] Reggio Emilia [23]
E-Learning	Anchored instruction [25] Constructionism [26]
	E-learning theory [27] Game reward system [28] Gamification [29]

Extraction Of Design Principles

We adopted grounded theory methodology for extraction of design principles. For this we purpose, we examined each domain of selected theories separately.

Constructivism

Design principles based on constructivist theory are explained below.

1)Sequential learning: The central idea of sequential learning is developed from the progressive development of a child's mind [30]. This sequential learning needs to be reflected in the learning framework in the following ways.

•Learning material must be disseminated to the learner in an incremental way ([43], [31]).

•Information requires to be delivered in linear sequence i.e., by beginning with simple tasks and moving gradually towards the advanced ones.

2)Scaffolding: Scaffolding is defined as the help and support required during learning [12]. Scaffolding can be applied to the framework as follows[43]:

•Teachers need to serve as facilitators while students are actively engaged in knowledge construction.

•Learners should be encouraged to collaborate and get support from each other.

Early Education

Various early education theories exist ([18], [32], [33], [34]) but this study is narrowed down to Montessori, Waldorf education, and Reggio Emilia. These theories offer the following principles:

1)Exchange of ideas: Reggio Emilia's approach insists on communication and idea sharing among students and with teachers. Design principles relevant to the exchange of ideas emphasize that ([38],[39]):

•Allow students to share ideas with each other for better understanding.

•Use visual and audio clues to support children in understanding new vocabulary and formulating ideas.

2)Learner control: According to Montessori [37], the uniqueness of children with respect to qualities and abilities demands their autonomy while learning. This autonomy of students can be promoted with the following design principles:

•Learning materials must be enriched with esthetically pleasing and nonviolent content in order to stimulate the child's interest and engagement, and also to maintain concentration.

•Learning content should also be appropriate according to the child's age.

•Provide learners with play and pause buttons to let them control their own learning pace.

E-Learning

E-learning theories also refer to as technology-oriented theories, are enriched with specialized principles which can be integrated into the design process to provide foundations for various technical elements of the e-learning system.

Following the design guidelines are developed from e-learning theories:

1)Short video introduction: Bransford et al. [25] introduced the idea of anchored instruction where anchor refers to a material or media, usually video. This video can be used in numerous ways [25]:

•Use a short video to introduce key discussion points of the lecture. This would be helpful in achieving instructional objectives.

•Video must be simple so that it may be understandable to students with different backgrounds.

•Video should integrate interesting elements so that students are willing to watch it again for learning purposes.

Inclusion of familiar objects:
Constructionism is a student-centered educational theory deep-rooted in discovery learning [26]. It is built on Piaget's constructivist theories with the notion of active knowledge construction through the provision of familiar objects [40]. Constructionism can be used by teachers in the classroom as a checklist for learning opportunities by adopting the following principles:
•Motivate students to learn by educating them with those objects with which they are already familiar.
•Use of familiar objects makes the thinking process more visible.
•Design activities based on prior knowledge of individuals and groups.
3)Association of Rewards with Learning: The concept of rewards introduced in game reward system theory is derived from theories of intrinsic motivation and presents structures of rewards and incentives while learning through games [28]. Rewards can also be offered in non-gaming environments to keep students motivated during knowledge acquisition. Rewards can be inserted in learning through games as follows [28]:
•Introduce rewards in games while carrying out learning activities through games.
•It will keep learners engaged for a longer time period.
4)Integration of gaming elements: The term gamification refers to the integration of gaming principles into learning and gamification theory provides the basis for applying gaming elements to learning [29]. These elements include fun, immediate feedback, providing an opportunity to master skills by offering levels, progress indicators in the form of points, badges, etc. [29]. These gaming elements can be applied to educational settings in the following ways [29]:
•Include medium-level challenges such as levels of games [41].
•Provide immediate feedback to students as they get into educational games.
•Integrate cognitive curiosity by providing incomplete information so that learners are left with strong cognitive motivation to bring completeness to their knowledge [41].
5)Cognitive Load Reduction: E-learning theory provides the basis for the reduction of cognitive load which refers to the amount of effort imposed on the mind due to the way a task is delivered [27] To overcome this mental load, e-learning theory is rested on several e-learning design principles [27]:
•Use of multimedia
•Place relevant information close together
•Segment long passages into small chunks
•Provide learners with play and pause buttons
•Learner should be able to navigate easily across the system

Thematic Analysis
After extracting all design principles, we analyzed whether any connection exists between the extracted principles and e-learning systems components (tasks, tools, interface). For this, we performed a thematic analysis of group design principles on the basis of their relatedness to the components. This relatedness specifies how each design principle can be applied in the designing of each of the three components. Therefore, each of the design principles was carefully examined to link to each component. The suggested mapping is presented in the next section.

Mapping between Design Principles and E-Learning System's Components
The thematic analysis helped to map principles with components in order to enhance the e-learning process. Following relatedness between components, and design principles is derived on the basis of how these components are targeted by each design principle to improve learning.

Table 2:- Proposed Mapping between Theoretical Design Principles and Components of E-Learning System.

Design Principles (DPs)	Description of DPs	Associated Component
DP - 1: Sequential learning	DP - 1A: Disseminate learning material incrementally	Task
	DP - 1B: The information must be delivered sequentially	Task
DP 2: Scaffolding	DP - 2A: Teachers need to serve as facilitators	Task
	DP - 2B: Encourage learners to collaborate	Task
DP - 3: Learner control	DP - 3A: Provide the learner with good control of error with the play and pause button	Tools
DP - 4: Exchange of ideas	DP - 4A: Allow students to communicate and share ideas	Task
DP - 5: Short video	DP - 5A: Introduce key points of a lesson with a short video	Tools

introduction		
DP - 6: Use of familiar objects	DP - 6A: Educate learners with their familiar objects in the lesson	Task
	DP - 6B: Learning tasks should be designed according to the previous knowledge of learners	Task
DP - 7: Rewards' involvement	DP - 7A: Integrate rewards while educating through games	Tools
DP - 8: Integration of gaming elements	DP - 8A: Introduce challenges in educational games in the form of different levels	Tools
	DP - 8B: Stimulate the cognitive curiosity of learners to promote productive learning	Tools
DP - 9: Cognitive load reduction	DP - 9A: Use video, audio, and text in a combination of two	Tool
	DP - 9B: Long passages should be broken into small chunks	Task
	DP - 9C: Place relevant information close together	Interface
	DP - 9D: Learner should be able to navigate easily across the system	Interface

Table 2 explains how each component of an e-learning system can be strengthened by integrating theoretical design principles. The proposed design framework is presented in figure 1.

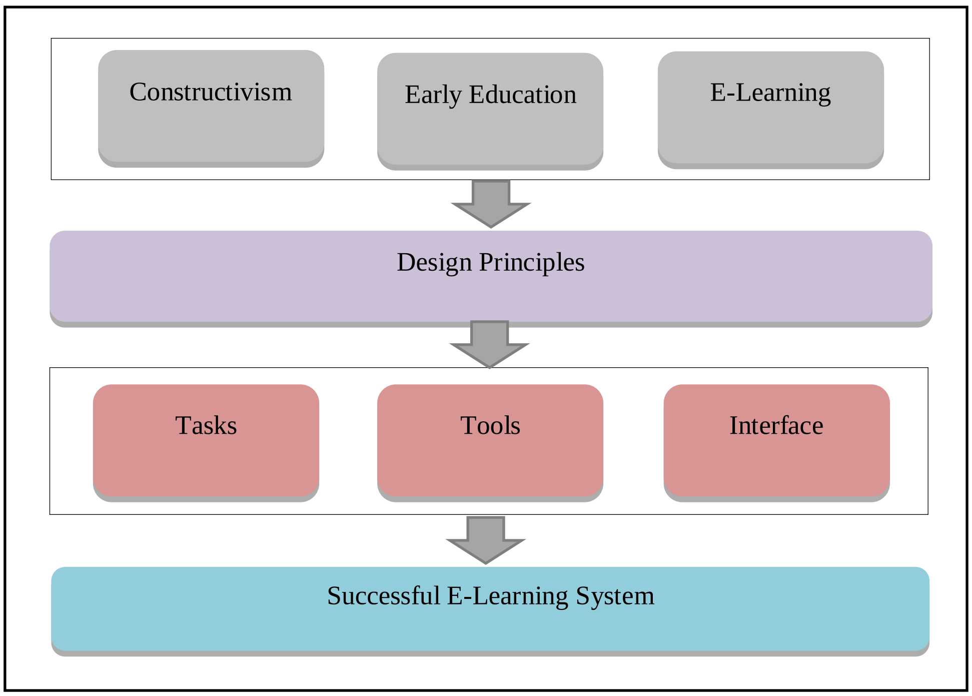

Figure 1:- E-Learning Design Framework based on Theoretical Principles and E-Learning System Components.

Framework Validation (RQ-2)

We developed an e-learning system for validation purposes named Qalamguru for primary students on the basis of proposed design principles. Detail of the system is given below.

Logging Module of E-Learning System

The e-learning system used structured logging to maintain a log of each activity performed. Log file stored all the essential information including user ID, each activity of the student, date of activity, time duration i.e., for how long the activity was done and the number of times an activity was conducted. Log file for each learning activity was maintained separately. The system provided an "Export" option to download CSV files for all activities or instructors could also obtain log files for any of the individual activities. The purpose of the log file was to explore those sets of activities that contributed to the success of primary students. We also analyzed those interactions of students which could not produce desired results for each grade (Grade 1 to Grade 5).

Participants

We conducted the experiment at a primary school with 394 students (aged from 5 to 11 years). The sample size was in accordance with the Power and Precision sample size of 387. The average number of students enrolled in each grade was 75 with three sections in each grade. The exact distribution of participants for each grade is depicted in figure 2.

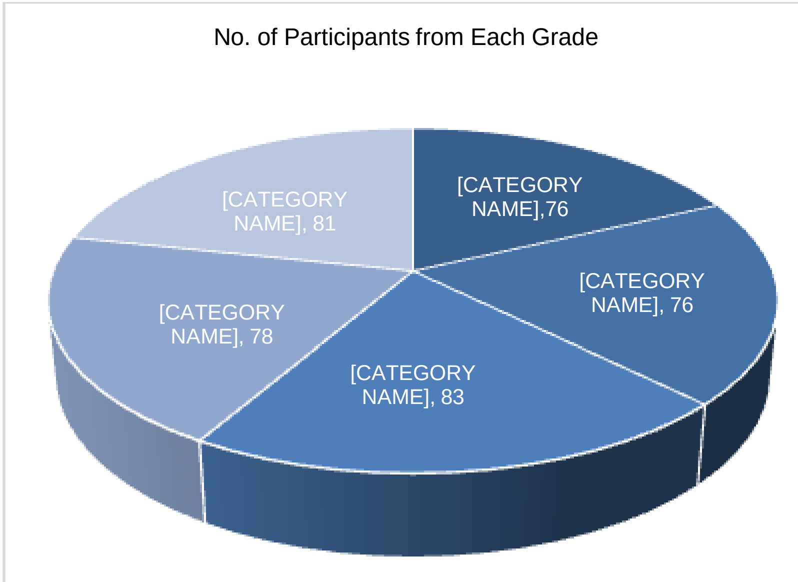

Figure 2:- No. of Students in Each Grade.

Experiment

Initially, a pre-test of students was conducted from all five grades to examine their prior knowledge. Each grade's test was based on 25 multiple choice questions (MCQs) from their Science curriculum. At first, all students were enrolled inan e-learning system in the Science course of their respective grade in order to let them get basic knowledge of science. Each student was provided with a username and password to login to the system. Teachers were present in the classroom just to assist them in login and sort out any issue faced by a student.Same sets of activities were added to the Science course of each grade. A brief description of each learning activity is described in table 3.

Table 3:- Description of Learning Activities.

Learning Activities	**Description**
Video	A short video presenting the main concepts of the topic.
Game	Multi-level game based on the contents of the lesson.
Chapter notes	Document covering detailed information of the lesson.
Key points	Powerpoint presentation containing important points of each lesson.
Discussion forum	A platform where students can post a question or reply to a post and discuss.
Exercise	Questions from the lesson are given in a separate document to let the students practice and assess their knowledge.

Each primary student used the system for a duration of 3 weeks. A log file was maintained while students were using the system. After 3 weeks, a post-test was carried out to measure students' learning performance. Each grade's post-test was based on 25 MCQs from their Science curriculum. The scores of pre-test and post-test were then compared to examine the impact of the e-learning system by finding the difference in their academic performance after using the system. The framework validation was done by separately analyzing students' log files of each grade in Python 3. We first performed preprocessing on the data as explained below:

Preprocessing

Data preprocessing involves data cleaning and data transformation. In data cleaning, noisy data and missing values are handled. There was no such data found since the log file was based on the students' interactions with learning activities through the system. So, at first, we imported necessary libraries including **NumPy** to deal with numeric data and seaborn for data visualization. Next, the log file was read, and the data were transformed as explained below.

Data Transformation

The log file recorded students' interaction details in the form of exact chapter notes e.g., "Chapter-3.docx" to show that a student viewed notes of Chapter-3. So, initially, we converted this activity (e.g., Chapter-3.docx, Chapter-1.docx, etc.) into a generic form as "View Chapter Notes" by using **replace** function. Similarly, all key points viewed were replaced with "View Key points" and all exercises were converted to "Attempt Exercise", respectively.

Data Splitting

In order to analyze each grade's data separately, we separated out rows of each grade. In the next step, we appended pre-test and post-test scores to compare students' academic performance against their activities. Then we calculated the score difference by subtracting the pretest score from the post-test score to investigate the impact of learning activities on students' learning who studied through our proposed system.

Data Encoding

We chose the FP Growth algorithm to explore common sequences of learning activities of students. FP Growth algorithm was preferred over the Apriori algorithm due to its efficiency in terms of less execution time and less memory consumption [42]. The algorithm facilitated the exploration of the recurring interaction patterns of successful and unsuccessful students. For this, we encoded data into 0s and 1s to make it compatible to apply FP Growth algorithm. Encoding was done by applying **encode** function which converted all number of activities performed for one or more than one time to 1, and all activities performed for zero time to 0. The same data encoding procedure was followed for each grade.

Results:-

Overall Academic Performance

The comparison between pretest and post-test scores indicated that students of each grade showed improvement in their academic performance after acquiring knowledge through a theoretical design principles-based e-learning system. Findings revealed that among 394 participants, 327 (83%) students got better scores, the performance of 21 (5.3%) students remained the same, whereas 46 (11.7%) of them scored low marks in the post-test. On average, the pretest score of Grade 1 students was 13.37 while they got a 16.5 score in the post-test. Grade 2 students attained 12.15 average marks in the pretest and 17.68 after post-test. The mean score of the pretest for Grade 3 was 14.4 which improved to 17.21 in the post-test. Grade 4 students showed the most significant improvement and got average marks of 19.3 in the post-test in contrast to 11.86 onthe pretest score. Similarly, Grade 5 students also had better scores in the post-test with a mean value of 18.49 in comparison to the average pretest score of 12.73. Average pre-test and post-test scores of all primary grades are depicted in figure 3.

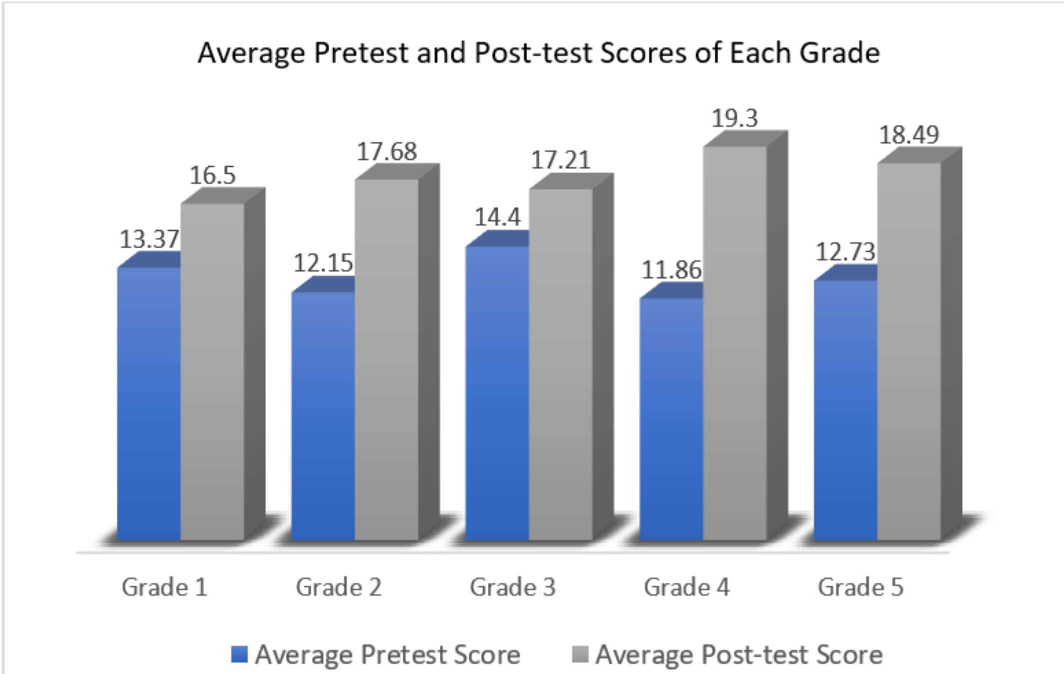

Figure 3:- Average Pretest and Post-test Scores of Primary Grades.

Performance of Each Grade

The academic performance of each grade was separately analyzed to figure out the impact of the e-learning system in terms of themaximum number of successful students and unsuccessful students for each grade. Among 76 students in grade 1, 59 of them showed improvement. The performance of 9 students remained the same, whereas 8 students showed a decline. There were 76 participants from grade 2. Out of them, post-scores of 57 students were improved, 14 got low marks while 5 of them showed no difference in their performance. In grade 3, 69 students out of 83 showed improvement in learning. There was no impact on scores of 6 students and performance declined of 8 students. Among 78 students in grade 4, 57 of them got better scores in the post-test. Out of the remaining 21 students, 9 had no impact on their learning, and 12 showed low performance. In grade 5, the performance of 60 students was approved out of 81. There were 13 students who got less post-test scores and 8 got the same scores on pretest and post-test.

Interaction Pattern Analysis

All students used the same set of activities for a predefined period (i.e., three weeks), however, there was a clear difference in their performance.Therefore, we obtained interaction patterns of successful and unsuccessful students in order to investigate their frequent patterns which led to their failure or success.

Interaction Pattern Analysis of Unsuccessful Students

In the case of unsuccessful students of grade 1, it was found that most of them had a discussion as a common activity mostly led by studying chapter notes. Another common pattern was viewing chapter notes followed by playing games. Other details of unsuccessful students of grade 1 are given in table 4.

Table 4:- Frequent Patterns of Low Scorers of Grade 1.

Support	Item Sets
1.000000	(View Chapter notes)
0.866667	(Post-Discussion)
0.733333	(Play Game)
0.800000	(Reply - Discussion)
0.866667	(View Chapter notes, Post-Discussion)
0.733333	(View Chapter notes, Play Game)
0.800000	(View Chapter notes, Reply - Discussion)

In grade 2, chapter notes, discussion, and practice exercises were most frequently accessed by unsuccessful students as presented in table 5.

Table 5:- Frequent Patterns of Low Scorers of Grade 2.

Support	Item Sets
1.0000	(View Chapter Notes)
1.0000	(Post-Discussion)
0.9375	(Attempt Exercise)
0.8750	(Play Video)
1.0000	(Post-Discussion, View Chapter Notes)
0.9375	(Post-Discussion, Attempt Exercise)
0.9375	(Attempt Exercise, View Chapter Notes)
0.9375	(Post-Discussion, Attempt Exercise, View Chapter Notes)
0.8750	(Post-Discussion, Play Video)
0.8750	(View Chapter Notes, Play Video)
0.8125	(Attempt Exercise, Play Video)
0.8750	(Post-Discussion, View Chapter Notes, Play Video)
0.8125	(Post-Discussion, Attempt Exercise, Play Video)
0.8125	(View Chapter Notes, Attempt Exercise, Play Video)

In grade 3, games were most frequently accessed, followed by chapter notes and exercises. Details are given below (with reference to table 6).

Table 6:- Frequent Patterns of Low Scorers of Grade 3.

Support	Item Sets
0.944444	(Attempt Exercise)
0.888889	(View Chapter Notes)
0.888889	(Play Game)
0.777778	(Reply - Discussion)
0.833333	(Attempt Exercise, View Chapter Notes)
0.833333	(Play Game, Attempt Exercise)
0.777778	(Play Game, View Chapter Notes)
0.722222	(Play Game, Attempt Exercise, View Chapter Notes)
0.722222	(Attempt Exercise, Reply - Discussion)

Among unsuccessful students of grade 4, the most frequently accessed activities were exercise and games (table 7).

Table 7:- Frequent Patterns of Low Scorers of Grade 4.

Support	Item sets
1.0000	(Attempt Exercise)
0.8750	(Play Game)
0.8125	(View Key points)
0.8125	(Attempt Exercise)
0.8750	(Attempt Exercise, Play Game)
0.8125	(Play Game, View Key points)
0.8125	(View Chapter notes, Attempt Exercise)

Lastly, in the case of grade 5, common activities of students with low scores were explored as discussion and attempting practice exercises. Complete pattern details are given below in table 8.

Table 8:- Frequent Patterns of Low Scorers of Grade 5.

Support	Item sets
0.944444	(Attempt Exercise)
0.888889	(View Chapter notes)
0.888889	(Play Game)
0.833333	(Post-Discussion)
0.833333	(View Chapter notes, Attempt Exercise)

0.833333	(Attempt Exercise, Play Game)
0.777778	(View Chapter notes, Play Game)
0.722222	(View Chapter notes, Attempt Exercise, Play Game)
0.833333	(Post-Discussion, Attempt Exercise)
0.777778	(View Chapter notes, Post-Discussion)
0.722222	(Post-Discussion, Play Game)
0.777778	(View Chapter notes, Post-Discussion, Attempt Exercise)
0.722222	(Post-Discussion, Attempt Exercise, Play Game)

Interaction Pattern Analysis of Successful Students

In the case of successful students of grade 1, it was found that most of them accessed video as a common activity mostly led by studying chapter notes. Another common pattern was playing games followed by exercise. Other details of successful students of grade 1 are given in table 9.

Table 9:- Frequent Patterns of High Scorers of Grade 1.

Support	Item sets
1.0	(Play Video)
1.0	(View Chapter notes)
1.0	(Attempt Exercise)
0.8	(View Key points)
1.0	(Play Video, View Chapter notes)
1.0	(Play Video, Attempt Exercise)
0.8	(Play Video, View Key points)
1.0	(Attempt Exercise, Play Game, Post-Discussion)
0.8	(View Chapter notes, View Key points, Play Game)
0.8	(View Chapter notes, View Key points)
1.0	(Play Video, Attempt Exercise, Play Game)
0.8	(Play Video, View Chapter notes, Play Game)
0.8	(Play Video, View Key points, Attempt Exercise)
0.8	(View Key points, Play Game, Attempt Exercise)
0.8	(Play Video, Attempt Exercise, View Key points)

In grade 2, game, video, chapter notes, and key points were most frequently accessed by successful students as presented in table 10.

Table 10:- Frequent Patterns of High Scorers of Grade 2.

Support	Item sets
0.9375	(Play Game)
0.9375	(Attempt Exercise)
0.8750	(Play Video)
0.8125	(View Chapter notes, View Key points)
0.8125	(View Chapter notes)
0.8750	(Play Game, Attempt Exercise,)
0.8125	(Attempt Exercise, Play Video)
0.8125	(Play Video, Play Game)
0.7500	(Play Video, View Chapter notes, Play Game, Attempt Exercise)
0.7500	(View Key points, Play Video)
0.7500	(View Key points, Play Game, Attempt Exercise)
0.7500	(View Key points, Play Game)
0.7500	(Attempt Exercise, View Chapter notes)

In grade 3, practice exercise was most frequently accessed, followed by chapter notes and learning games. Details are given below (with reference to table 11).

Table 11:- Frequent Patterns of High Scorers of Grade 3.

Support	Item sets
1.000000	(Attempt Exercise)
0.941176	(Play Video)
0.941176	(Play Game, Attempt Exercise)
0.882353	(Play Game)
0.823529	(View Key points)
0.823529	(View Chapter notes)
0.882353	(Attempt Exercise, Play Video)
0.823529	(Play Game, Play Video)
0.823529	(Play Video, Attempt Exercise, Play Game)
0.823529	(Play Video, View Key points, Attempt Exercise)
0.823529	(Play Video, View Chapter notes, View Key points, Play Game)
0.823529	(View Chapter notes, Attempt Exercise)
0.823529	(Play Video, View Chapter notes, Attempt Exercise)

Among successful students of grade 4, the most frequently accessed activities were chapter notes and games (with reference to table 12).

Table 12:- Frequent Patterns of High Scorers of Grade 4.

Support	Item sets
1.000000	(View Chapter notes)
0.882353	(Play Game)
0.823529	(View Key points)
0.823529	(Reply - Discussion)
0.764706	(Play Video)
0.823529	(Post-Discussion)
0.882353	(Play Video, View Chapter notes, Play Game)
0.823529	(View Chapter notes, View Key points)
0.705882	(Play Game, Attempt Exercise)
0.705882	(View Chapter notes, View Key points, Play Game)

Lastly, in the case of grade 5, common activities of students with high scores were explored as attempting practice exercises, viewing chapter notes, and playing games. Pattern details are given in table 13.

Table 13:- Frequent Patterns of High Scorers of Grade 5.

Support	Item sets
1.000000	(Attempt Exercise)
0.882353	(View Chapter notes)
0.882353	(Play Video)
0.764706	(View Key points)
0.764706	(Reply - Discussion)
0.705882	(Post-Discussion)
0.823529	(Play Game)
0.882353	(View Chapter notes, Play Game, Attempt Exercise)
0.882353	(Attempt Exercise, Play Video)
0.764706	(Play Video, View Chapter notes)
0.764706	(View Key points, Play Game, Attempt Exercise)
0.764706	(View Chapter notes, View Key points)
0.764706	(View Chapter notes, Reply - Discussion)
0.764706	(Reply - Discussion, Attempt Exercise)

In comparison to low performers, it was found that students who displayed significantly positive results had some frequent patterns in common among all grades as shown below:

(Play Video, View Chapter notes), (View Key points, Play Game), (View Chapter notes, View Key points), and (Play Game, Attempt Exercise). On the basis of these four patterns, it was inferred that following pattern was common in successful students of all grades (figure 4):

Figure 4:- Sequence of Learning Activities followed by Successful Students of All Grades.

The above-mentioned pattern was provided to all those students of each grade who either got the same pre-test and post-test scores or those who got low scores in the post-test. At first, students accessed the e-learning system through a provided sequence of activities for a period of three weeks for the Science subject. After three weeks, they were asked to attempt a post-test. It was found that students of all grades showed improvement. In grade 1, 12 out of 17 got better results than before. In grade 2, 16 achieved higher scores and 3 students could not improve. Grade 3 students 9 out of 14 scored high scores while in grade 4, 15 students among 21 showed better results. Lastly, in grade 5, 17 showed improvement and only 4 students got low scores. So, overall, among 92 low achievers of all grades, 69 showed improvement after following a predefined sequence of activities. Therefore, it can be concluded that a theories-based e-learning system can further enhance the e-learning process by accessing learning activities through a sequence.

Discussion And Conclusion:-

The main purpose of this research is to enhance e-learning systems for primary education by applying learning and e-learning theories. For this purpose, a comprehensive framework was proposed. The framework consisted of nine sets of design principles based on learning and e-learning theories. The framework was validated by integrating these principles into an e-learning system. The system was then delivered to a primary school where each primary grade was given access to it for a period of three weeks. It was concluded that an e-learning system has great potential in primary education and can assist educators and practitioners in achieving desired learning outcomes by integrating educational theories. Our first main finding was the set of those learning and e-learning theories which can be utilized for designing e-learning systems in the context of primary education. These theories were finalized through a proper selection procedure.

Another key finding of our studies is the identification of underlying associations between learning and e-learning theories and the e-learning system’s components including tasks, tools, and interface. We developed a framework to present how each design principle can be applied to each component in order to strengthen an e-learning system. E-learning tasks can be performed effectively by circulating learning material in an incremental way and sequential distribution of information. Tasks can further be done productively if teachers serve as facilitators and learners are allowed to collaborate and communicate. Other ways to accomplish tasks are by educating learners with familiar objects and designing tasks based on learners’ previous knowledge. Learning tools can contribute to the productive e-learning process more successfully if based on design principles. In this regard, the video should be kept short to provide an introduction tothe lesson. It should also include play and pause buttons to provide learner control and must include either audio or text, but not both. A discussion forum can be used to promote communication and support ideas sharing among students. Educational games can produce more fruitful outcomes by including rewards and challenges and invoking cognitive curiosity. Lastly, the interface of an e-learning system can be more useful if a learner is able to navigate easily across the system and related information is placed close together.

We validated the framework by evaluating primary students’ academic performance in association with their interaction patterns. Secondly, we looked into the sequence of learning activities of successful and unsuccessful students was compared. It was revealed that the sequence of learning activities plays a vital role in the achievement of a successful e-learning process. Moreover, the use of a short introductory video lecture at the beginning of the lesson followed by detailed chapter notes promotes effective learning. Use of key points to enforce important information is also beneficial along with playing educational games. Lastly, practice exercises can assist learners in their self-evaluation. Our research findings can assist educators and practitioners while developing and utilizing e-learning systems for primary students.

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None.

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