Instructional Approach for Effective e-Content: Impacting Teaching and Learning through Educational Website

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Abstract

Educational e-Content has become an all-pervasive element of learning and teaching today. Now, there is abundant e-Content available for students and teachers. However, the instructional effectiveness of any e-Content for meeting the specific needs of learners and teachers is still an area of concern. The study has been conducted to develop an effective e-Content for learners of Chemistry. It focused on devising learner-specific instructional strategies under the ADDIE instructional system design model. The researchers designed an educational website to make the e-Content of Chemistry accessible anytime and suitable for future modification. The study progressed in two phases; the development phase and the experiment phase. While the study was primarily undertaken to develop and evaluate quality e-Content, it also confirmed the need and ways for teachers to become instructional designers in its course. It discusses the need analysis, content analysis, storyboarding, and instructional analysis in the development phase. The effectiveness of e-modules of chemistry developed was evaluated in the experiment phase by employing an actual experimental research design. The study establishes the efficacy of e-modules in Chemistry developed by adopting the "ADDIE model of instructional design". It also highlights the need for teachers to practice instructional design for developing contextualized e-learning solutions. The teacher-designed instructional learning systems can best contribute to developing effective e-Content for learners.

KeyWords: e-content,Instructional Design, ADDIE, educational website, e-module

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Introduction

Instructional e-Content has shown phenomenological growth in its range and reach over the last few decades (Hamid et al., 2021). No fragment of teaching-learning scenarios today is without the impact of e-Content. E-learning and e-Content are bringing new solutions to the classrooms daily (Jaleel, 2015; Nachimuthu, 2018; Almelhi, 2021; Al-Hunaiyyan, et al., 2021). However, these advancing teaching-learning scenarios put a great onus on the teachers to upgrade their technical knowledge along with their teaching skills (Mandora, 2017). Accounting evolution of e-Content along with Information communication Technology, Sharma and Rawat (2017) suggest that a paradigm shift in the idea of the development of e-Content has happened. New age e-Content demands the involvement of the affective domain along with a creative and scientific approach (Mishra et. al., 2017). Understanding and capturing users' emotional needs can be best done by the teachers. That is why teachers need to understand instructional design to capture the micro instructional needs of learners in the context of their immediate environment (Qasem, & Nathappa, 2016; Deepika, 2021).

In this regard, the study presents guidelines to teachers to take up instructional design as their prerogative by giving step-by-step details of Instructional System design Models. The study progresses in two distinct phases as development phase and the experiment phase. Each phase of the study diligently follows the "steps of the ADDIE model of instructional System design". Through the development phase of the study teachers can recognize the ways to think of an innovative idea, convert it into a storyline, put characters into it, choose the right media components like text, audio, and animation, and design effective instructional strategies. They can realize the importance of educational website and innovative instructional strategies to deliver effective e-Content to the learners. The experiment phase of the study assesses the effectiveness of e-Content developed as e-modules of Chemistry through an experimental study. To elaborate on the study, this paper comprises of following sections: literature review, plan of the study, methodology, results, discussion and conclusion, and references.

Literature Review

Edifice the well-intentioned e-content for teaching and learning has recently bumpy as a foremost challenge throughout the world. Conferring to Nuryadin, Lidinillah, & Muharram (2021) regarding digital learning design in the Covid-19 pandemic, instructional designers try to find out the utmost tools and the most reliable pedagogical principles to create the perfect e-content.

According to Khojasteh, et.al (2022) covid-19 pandemic teaching experiences demand the

evaluation of the excellence of e-content development to offer a variety of short-term e-learning courses. To get responses from students about the worth of e-content used by their teachers; a researcher-devised questionnaire with 30 items was employed on 610 undergraduate students of Medical Sciences faculties. The result revealed that the students had satisfactory high scores and had a satisfactory viewpoint on the various dimensions of e-content quality. Various other studies also confirm increased achievement across various disciplines along with positive perceptions of e-content-based teaching and learning. The study conducted by Hamid, et.al (2021) regarding e-content-based instructional modules for the Chemistry MOOC course exposed positive results. The study established positive and high perceptions of students on the e-content instructional modules for Chemistry MOOC in terms of content, useableness, strategy, and effectiveness. The study of Prabakaran (2021) also confirmed the effectiveness of mathematics e-Content-based learning modules. The experimental study with Solomon's four-group design was conducted on 80 school students. The results were collected by administering an academic achievement test in mathematics. The findings explored that the e-content module was more operational in concretizing and hypostatizing the concepts of mathematics and positively influenced student achievement. Many more studies have captivated the effectiveness of e-content representing subject areas such as Environment education (Mishra, Patel & Doshi, 2017), Mathematics (Albina, 2018), and Biology (Nachimuthu, 2018), and alike. Therefore, it is evident from the available literature that e-Content-based learning and teaching are the need of the hour for all disciplines. Also, the various dimensions of quality of e-Content developed are important criteria for satisfactory e-learning experiences.

There are more studies that confirm the necessity of an appropriate instructional system design model for effective e-Content development. The quasi-experimental research by Almelhi (2021) intended to scrutinize the effectiveness of the ADDIE model within the online teaching-learning setting. Sixty students studying in the English department were randomly selected for the study. The intervention was administered to assess the effectiveness of e-learning environments in expanding students' creative writing skills. The results demonstrated significant changes in writing performance through post-testing of the experimental group participants. There are studies also focused on the development and validation of the e-content at various levels of education (Muruganantham, 2015; Hamdi & Hamtini 2016) that proposed an instructional framework for effective e-Content development. These studies evidently mandate the adaptation of instructional design for effective e-Content development.

There are also studies indicating the use of websites as a highly effective mode of e-Content-based learning. Soroya & Ameen (2020) inspected the reading behaviour of university pupils within the

digital age of millennials living in Pakistan. The research employed a cross-sectional survey on 515 postgraduate students selected through a stratified purposive sampling method. The findings indicated that Millennials preferred electronic reading content which is available in the "public domain and open access" as freely available on websites in spite of their preferences for print material. The study showed that the digital environment with the increasing usage of e-Content, social networking websites and search engines such as Google have a significant influence on pupils' reading behaviour. The study by Tan (2019) focused on E-tutoring websites with superior technology to enhance authenticity and examine communication language. The literature review indicates the need for the development effective of e-content for school students. It justifies the design of the study by employing appropriate instructional design and developing the website for the study.

The study aimed to develop effective e-modules in the chemistry based on the ADDIE instructional design model developing a website and assess them through an experimental study under two distinct phases namely developmental and experimental phases. The specific objectives to achieve the aims of the study are:

1. To develop effective e-Content modules on chemistry topics for students of the tenth class.
2. To examine the effectiveness of e-Content modules on chemistry topics for students of the tenth class.

Plan of the Study

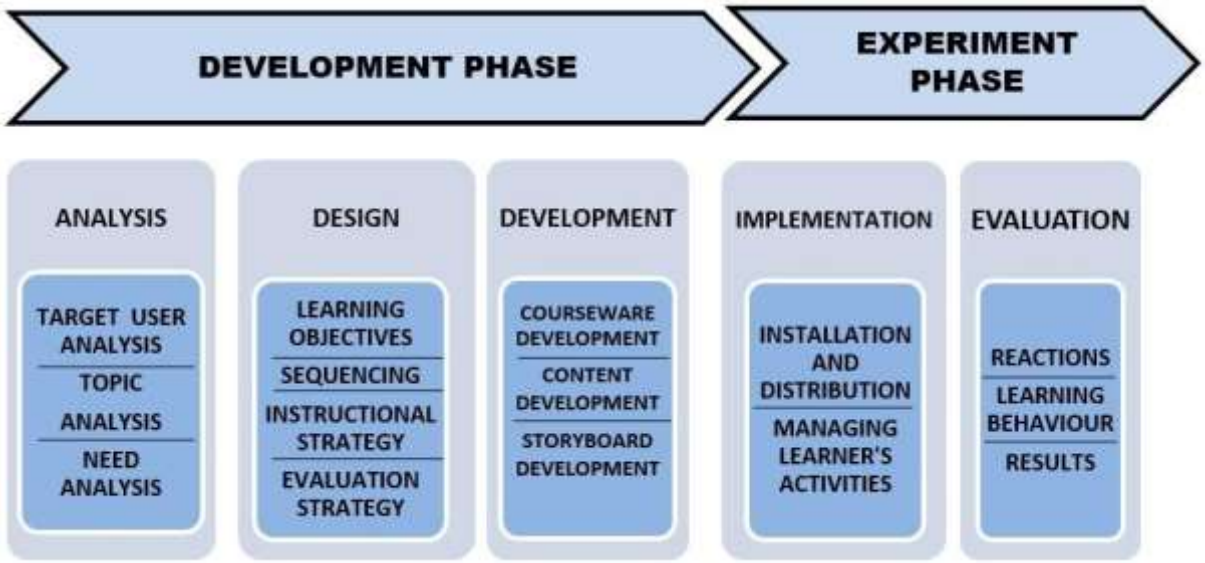
The general plan of the study was executed under the "five steps of the ADDIE model of instructional design" which has been carried out in two distinct phases *(i) the development phase and (ii) the experiment phase.*

The study was a two-layered study with the following steps and activities of the ADDIE instructional design model.

(i) Developmental Phase

To achieve the first objective of the study; **the development phase** was completed under the analysis, design, and development steps.

Figure 1. Plan of the Study Incorporating the ADDIE model of Instructional Design



ADDIE model: Analysis. The analysis phase intensely deals with the problem domain of content development and can be called a goal-setting stage. It identifies the problems and objectives of the project undertaken. As per the ADDIE model format, the study performed the analysis of target users and suitable topics for e-content, and need analysis with experts. The students and teachers from the population of the study were interviewed by gathering their responses through a need analysis questionnaire. It contained three open-ended descriptive questions about the need for e-content development, suitable topics from Chemistry for e-modules, and expectations of students and teachers for effective e-Content.

Table 1. Summary of prominent suggestions from need analysis

Dimensions of the questionnaire	Prominent suggestions
1. Need for e-content development	• There is an urgent need for e-content development • NCERT textbook chapters should be presented in a new way. • Abstract and micro-level concepts should be considered • Science teachers can use it for teaching and assessment.

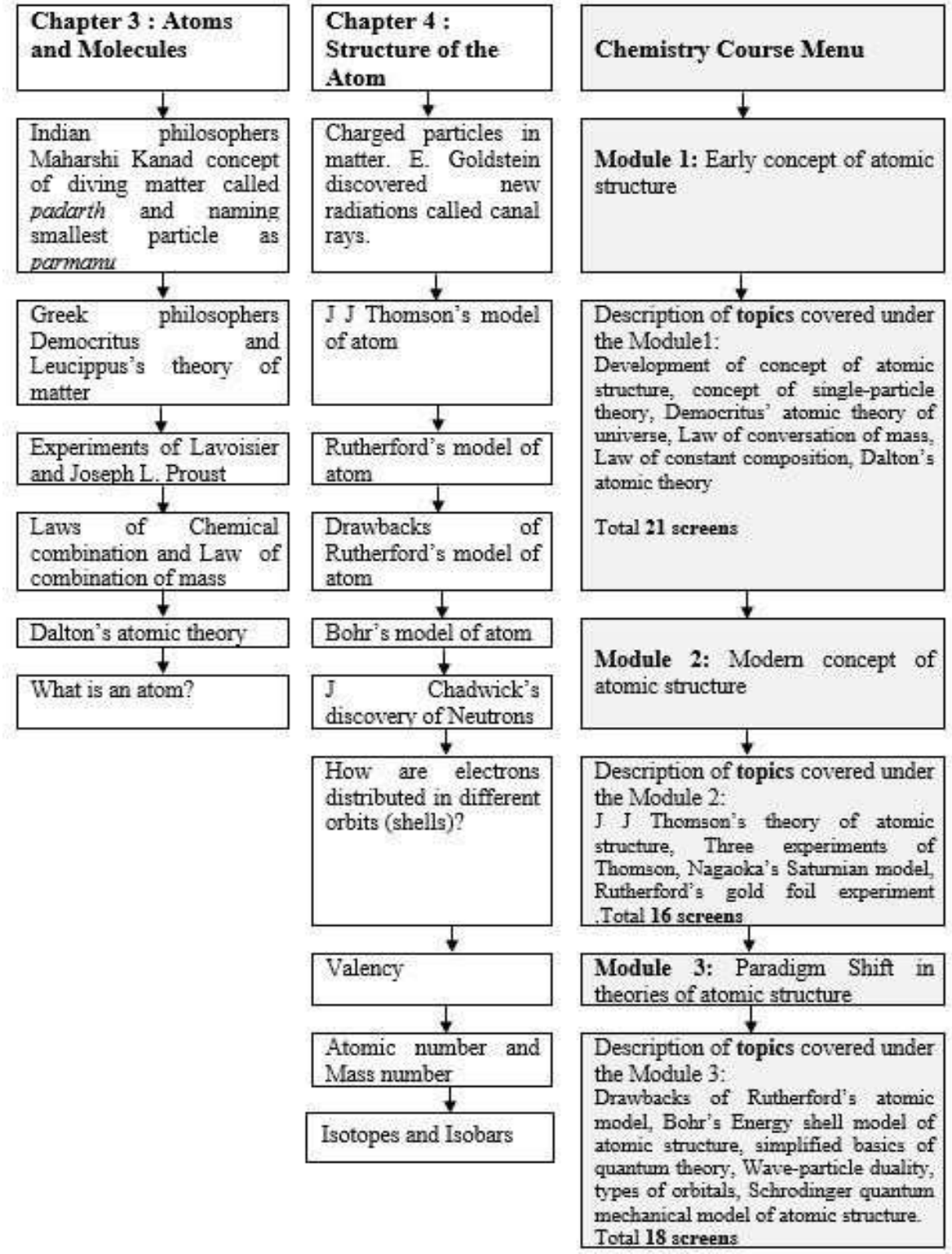
2. Topics for e-Content development	• Periodic Table • Atomic structure • Elements
3. Expectations from effective e-Content	• Main points should be highlighted. • It should be simple. • Content analysis should be done. • Creative and interesting content. • Should be present in small parts to facilitate note-taking. • Provision for assessment. • Audio, video and animation should be there but not overloaded with activities or animations. • It should remove the learners' need of taking tuition after school time.

As the analysis phase ends, there are clear answers to 'what' questions about the content, characteristics of the users, and needs of the users. The next step in development comes out to be the design phase.

ADDIE model: Design. The designing process of the ADDIE model is the most intensive phase of the preparation for the development of the e-Content. "The design phase deals with learning objectives, assessment methods, exercises, content, subject matter analysis, and media selection". The study achieved this step of the ADDIE model through major sub-processes of identifying learning objectives, sequencing, instructional strategy, and evaluation strategy. This is the step where content analysis of the selected topic is performed. For the study, the topic of atomic structure from Chemistry was selected as it is a micro-level abstract concept. The chapters prescribed in the textbook of the National Council for Education and Research; Government of India under the Central Board of Education (CBSE) run schools were selected. The reason was that CBSE is the most implemented Board of School Education in India and its curriculum is adopted by all major schools across the nation.

For deciding the structure and content of the final e-modules of chemistry, content analysis of NCERT textbook chapters was done. It built the foundation of the content prevalent on the topic of Atomic Structure. The study took a different flow of e-modules sequences applying the logic from the most primitive to recent development. It captured the Greek ideation of the atomic structure to the modern concept in terms of the Schrodinger quantum mechanical model of atomic structure. The e-modules were arranged to create a visualization of the electrons cloud without the exact calculation of complex equations. The comparative sequence of content analysis to present a clear idea of content analysis is as follows:

Figure 2. ***Comparative sequencing of NCERT textbook and e-modules of the study***



As the e-modules structure, number and content get clear and the number of screens per e-module is decided, learning objectives are clearly stated and the next step of the ADDIE model begins. The

next important activity is deciding on instructional strategies. Based on suggestions from the need analysis, the various micro instructional strategies were planned.

Instructional strategies. "Instructional strategies are techniques that teachers use to help students become independent learners". e-modules of Chemistry have been kept balanced in terms of content and animation. That is why the format of the modules has been kept to a moderate number of animations with concept-dominant content supported by the audio.

Virtual instructor. There was a virtual instructor to guide the students through the modules. e-modules are of the self-directed online tutorial type with easy navigation for learners for backward and forward screens according to their learning needs.

Narrative technique. Narratives have been employed while moving across the e-modules. It is a story or an incident according to the sequence of events in time. Screens in e-modules are arranged with the same idea. In Chemistry, narration regarding e-modules begins with the life of Democritus and the story of the genesis of the explanation of the atomic structure. The last e-module ends with Schrödinger's electron cloud model of the atom. It has been well-woven in a correlated manner through the means of virtual instructors that explains why every time a new theory for the atomic structure was required.

Biographical method. Theories of various scientists about atomic structure have been described by recounting their real-life experiences. Some examples from the modules are 'Narration of Democritus' walk on the beach, 'Thomson's background of Physics', and 'Robert Hooke's discovery of cell'.

Just-A-Minute (JAM) activities. In addition to the above strategies, some quick activities have been made part of the modules. Following is one such example from the storyboard of chemistry:

Figure 3: *Storyboard of Chemistry representing JAM activity*

Module 1: Early concept of Atomic Structure

Screen 4: Concept of Atomic Structure
Activity 1(Male voice) Before starting this discussion, let us all perform a small activity. Take a page of paper and tear it into two halves. Pick these two halves and again tear each of them off into two half pieces. Keep repeating this with each half until you reach a point where halves cannot be torn further. **What do we call this smallest indivisible part; we get at the end of the activity?** **(Female voice)** The answer to this question lies in the coming sections of the module. The first concept of atomic structure emerged very much from the way you performed this activity. Let us now know it in detail from the beginning.

The actual web page screen has this activity in an animated manner where some part of the text flashes back and forth.

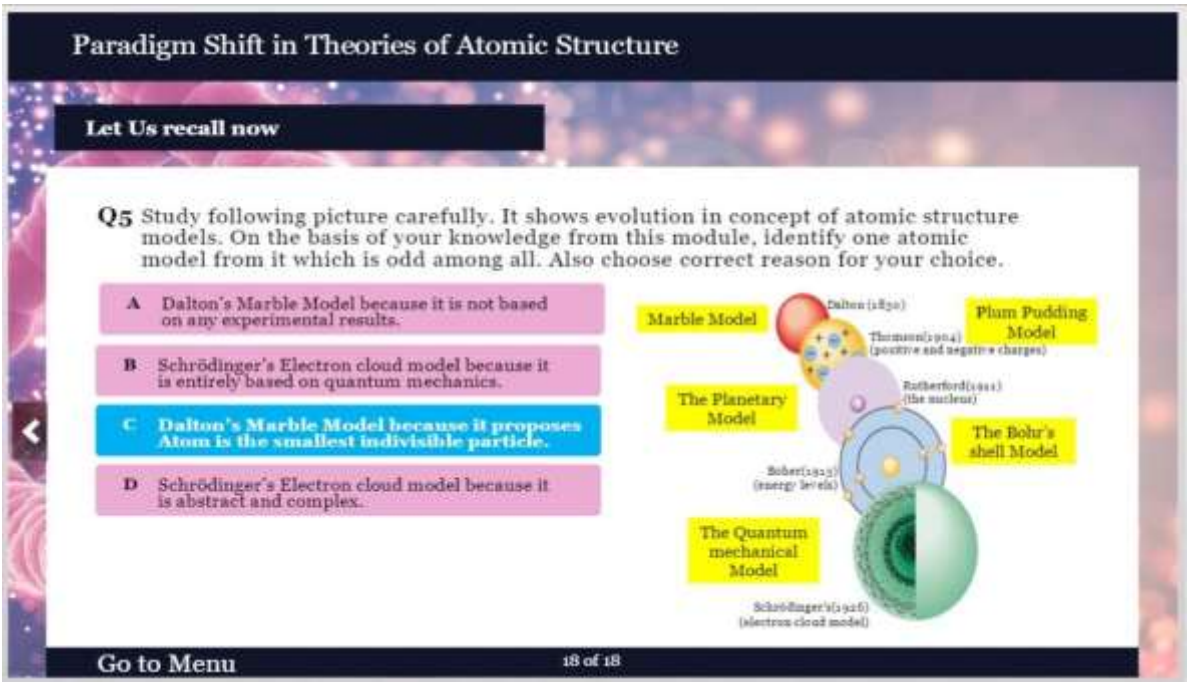
Picture clues and real-life illustrations. Another instructional strategy imbibed in the e-modules

has been the use of direct questions presented in the form of pictures based on daily life experiences. These clues have aided in fixing students' attention and preparing them mentally for a new topic.

Male and female voice as audio. The text of the e-modules has been supported by audio voices of alternating male and female voices to keep the interest of the students.

Evaluation strategies. The last activity of this step is the evaluation strategy. For this, evaluative screens have been designed fulfilling learning objectives established at the beginning of the process. The characteristic features of evaluative screens are that the equal number of five evaluative screens per module is there, an easy-to-difficult level of objective type questions was kept, and screens are a mix of knowledge-based, understanding-based, and application-based objective types of questions.

Figure 4. ***Chemistry Module 3-Evaluative screen no.5***



ADDIE model: Development. The development step consists of content development and courseware development. The content development is achieved through storyboarding. Storyboarding is defining each element of a screen/slide in terms of entry, exit, form, colour, and time. A storyboard is a series or set of a graphic organizer in the form of drawings, images, sketches, illustrations with some direction and dialogue displayed to show an outline of the story for the purpose of "pre-visualizing a motion picture, motion graphic, animation, or interactive media sequence". A storyboard should convey; what characters are there in the frame and how are

they interacting? How and where images/texts are coming and leaving the frame, and how much time has passed between the last frame and the current one?

There are also various applications available for storyboarding. The simplest way for a beginner like a teacher can be to make a storyboard in MS Word according to their need. A generic template for storyboarding screens from the study is as follows:

Figure 5. ***Generic template for storyboarding for an instructional screen***

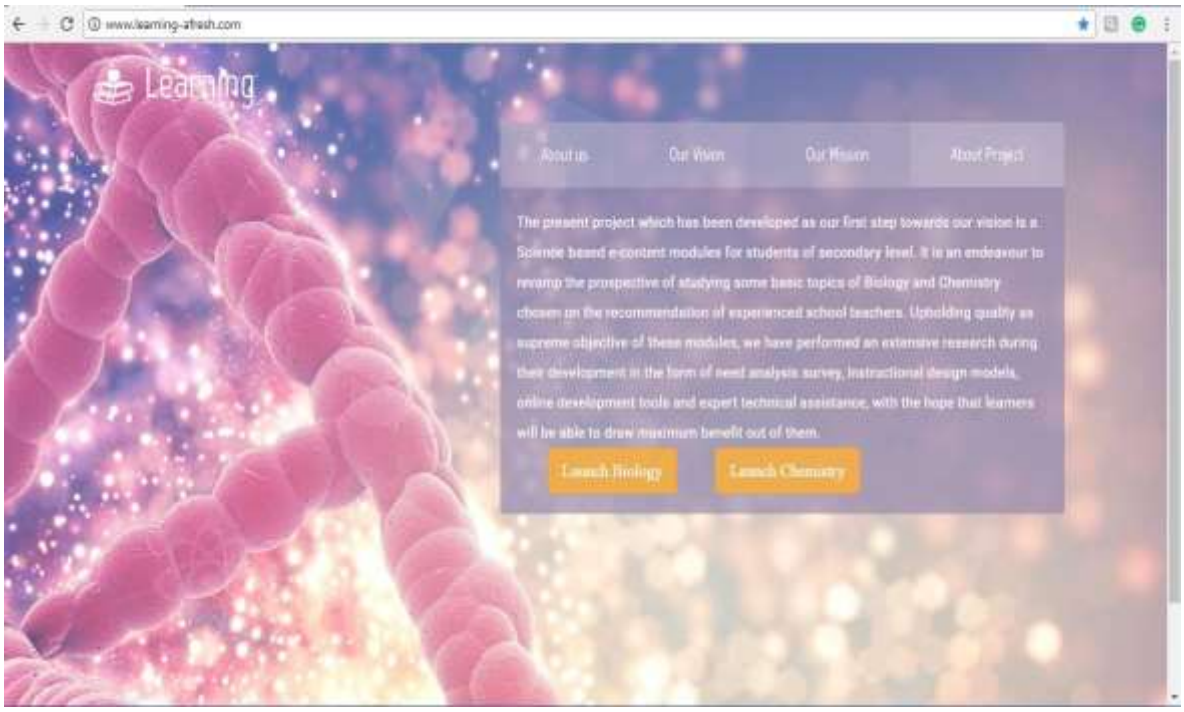
[Title of the module]
[Heading of the screen]
[Speech of the character as a virtual instructor or a voice with/without animation] **OR** **Text with/without animation** (Introduction of the topic connecting it with the previous knowledge and interesting facts related to the topic) • [**text line 1** with/without **a voice** with important definitions, terms and explanations highlighted] [related **image** if applicable] • **[text line 2** with/without **a voice** with explanations highlighted] [related **image** if applicable] • **[text line n** with/without **a voice** with explanations highlighted] [related **image** if applicable] [related **tables wherever** applicable]
Go to Menu **[slide no.] of [total no. of slides]**

The last activity of the development phase and development step of ADDIE is courseware development. Courseware means software programs or other materials specially developed for use in a training course or for educational purposes. Courseware for educational material is made in the form of kits meant for teachers/ trainers or tutorials for learners to be used with a computer. It could include materials for instructor-led classes, self-guided computer-based training, educational websites, content for live online classes, or educational videos.

The website developed for the study as courseware is to make freely available quality e-content for the learners. For this user interface of the website was kept laptop, as well as Smartphone,

enabled supported by least 3G internet data services. The Title of the website has been chosen by the researcher to be www.learning-afresh.com to signify the innovative teaching-learning approaches. Following is the screenshot of the website www.learning-afresh.com:

Figure 6. ***Screenshot of the Website www.learning-afresh.com***



The researcher, as an instructional designer, designed the website with the conceptualization of all the text, images, tabs and options. Once the concept design of the website was prepared, web hosting and domain name were purchased, and the website was launched with the help of a competent web developer.

(ii) Experimental Phase

The second objective of the study was achieved in **the** experiment phase, which is the implementation and evaluation steps of the ADDIE instructional design model. Students' and teachers' feedback was collected while administering the intervention, and evaluation was done through experimental research design, control and experiment groups.

To assess the effectiveness of the e-Content modules in chemistry topics developed, a systematic research methodology has been adopted to generalize the results. The description and data analysis are given below;

Methodology

Hypotheses

In order to fulfil the study's second objective, the following hypotheses have been formulated:

1. The mean scores of pre-tests of the control and experimental groups are not significantly different for Chemistry e-modules.
2. The mean scores of the pre-test and post-test of the control group are not significantly different for Chemistry e-modules.
3. The mean scores of the pre-test and post-test of the experimental group are not significantly different for Chemistry e-modules.
4. The mean scores of the post-tests of the d the experimental group are not significantly different for Chemistry e-modules.

Participants

The study's participants were secondary–level science students. A simple random technique has been adopted for the present study to select 60 students of the tenth class as a sample for the assessment of the e-modules of Chemistry. Out of 60 students, 30 students were assigned each to the control and experimental group.

Ethical declaration:

Before conducting the experiment the approval has been taken from the school authority to ensure the for is non-discriminatory during the intervention based on gender, race, and language. Participants were well aware of the purpose of the study and the intervention.

Research Design: Experimental research method has been used to carry out research to compare the effectiveness of instruction using e-Content of Chemistry with the traditional classroom teaching in terms of students' achievement before and after the experiment. The "randomized pre-test and post-test control group design" was adopted**.** In this design, two random samples are drawn, one controlled group & second experimental group, on the basis of a standardized intelligence test by Dr Srinivasan.

Instruments

The instrument for this current study included the Verbal test of intelligence and a research-made achievement test in Chemistry. The verbal Intelligence test by Dr Srinivasan was employed for making equivalent groups for the experiment. On the basis of similar IQ levels, participants were assigned randomly on the basis of the lottery system to control and experimental groups.

Consequently, a self-constructed and standardized achievement test in chemistry was used to check the degree of the performance of thestudents before conduct the experiment and after completion of the experiment. For standardization of chemistry achievement, test content validity, face validity, and Reliability of the instrument was established. Reliability of the achievement test by split-half method obtaining reliability coefficient values of Reliability was calculated through the split-half method to be r=0.81and rtt=0.89.

Data Analysis

To accomplish the core objective of the research "to examine the effectiveness of e-content modules in Chemistry topics for students in the tenth class", it was crucial to calculate the significance of differences between pre-test and post-test scores on academic achievement of both experimental group and control group. Therefore, a one-sample t-test was used to determine the significance of the differences in the respective mean scores of collected data.

1. **The mean scores of pre-tests of the control group and the experimental group are not significantly different for Chemistry e-modules.**

A comparison of the mean component of the learner's pre-test scores of the experimental and control groups of Chemistry e-modules based on a one sample-test can be seen in Table. The mean and standard deviation of the learners' perspective (N=40) are demonstrated below;

Table 2 *Significance of pre-test scores in control and experimental groups of Chemistry e-modules*

Group	No. of students	Mean	SD	t	p-value (at 0.05 level of significance)
Control Group	20	37.9	4.88	**0.47**	2.02
Experimental group	20	38.6	4.48		

The value of obtained t is 0.47, less than the p-value of 2.02 at the 0.05 level (P>0.05). Nonetheless, there was no significant difference in the pre-test scores of students in terms of their academic achievement. Thus, the null hypothesis is accepted. Therefore, it is deemed that before given the treatment of instruction with e-content, both the groups were almost of the same ability.

2. The mean scores of the pre-test and post-test of the control group are not significantly different for Chemistry e-modules.

The researcher used an independent t-test to compare the mean scores of students of the control group based on their pre-test and post-test. The mean and standard deviation of the obtained scores from the learners' perspective (N=40) is displayed in table 3.

Table 3 *Significance of pre-test post-test scores of the control group of Chemistry e-modules*

Test	No. of students	Mean	SD	t value	p-value (at the 0.05 level of significance)
Pre-test	20	37.9	4.88	**1.26**	2.02
Post-test	20	39.85	4.9		

The analyzed data in table 3 confirmed that the obtained t value is 1.26, which is less than the p-value of 2.02 at the 0.05 level ($P > 0.05$). Hence, null hypothesis 2 is accepted. Results showed no significant differences in the arithmetic mean and standard deviation of pre-test and post-test scores of the control group. It can be interpreted that the control group remained at the same achievement during the experiment because of the absence of the treatment.

3. The mean scores of the pre-test and post-test of the experimental group are not significantly different for Chemistry e-modules.

To test the hypothesis for significance and compare the mean scores of pre-test and post-test scores of the experimental group of Chemistry e-modules, the independent t-test was used.

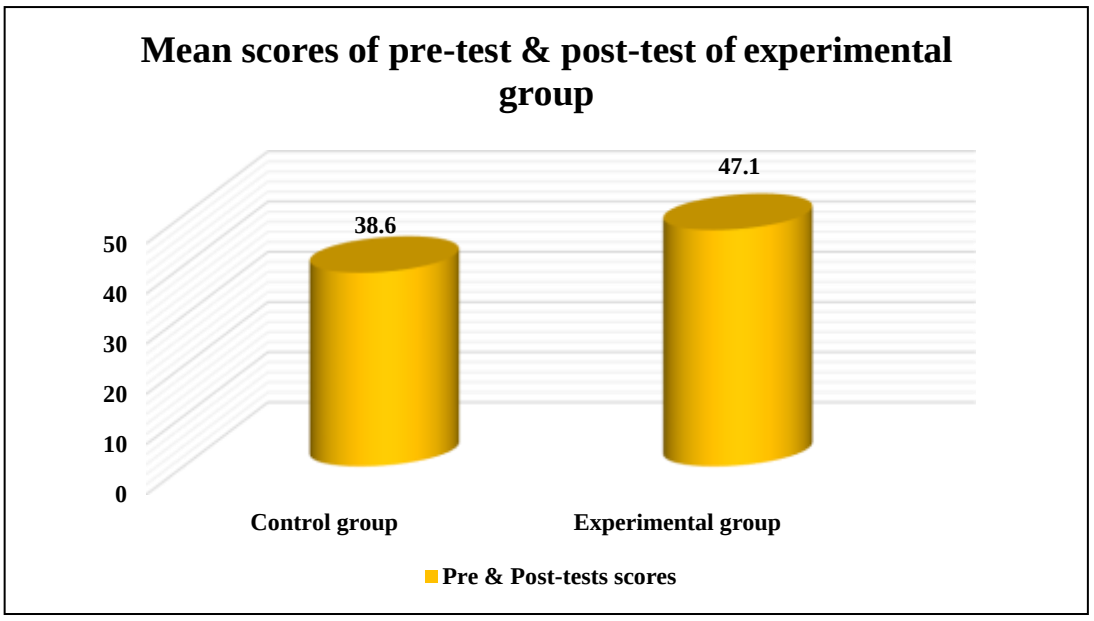
The obtained scores results mean and standard deviation from the learners' viewpoint (N=40) is presented in table 4.

Table 4. *Significance of pre-test and post-test scores of experimental groups of Chemistry e-modules*

Test	No. of students	Mean	SD	t	p-value (at the 0.05 level of significance)
Pre-test	20	38.6	4.9	**5.86**	2.02
Posttest	20	47.1	4.7		

The obtained "t" value is 5.86, which is more than the table p-value of 2.02 at the 0.05 level (P>0.05), so null hypothesis 3 is rejected. The difference between the mean scores of pre-tests and post-test is significant. Therefore, after receiving intervention with access to chemistry e-modules, the student's response in the experimental group was higher. It implies that the accessibility of Chemistry e-modules in the experimental group shows a significant rise in achievement during the experiment.

Figure 6. *Graphical representation of the "Pre & Post-test scores in Experimental and Control groups."*



4. The mean scores of the post-tests of the experimental group are not significantly different for Chemistry e-modules.

Independent t-test was employed to investigate significance in the mean of pre-test and post-test of control and experimental group of test scores with instruction of chemistry e-modules. The obtained results of mean and standard deviation from the learners' stance (N=40) are offered in table 5.

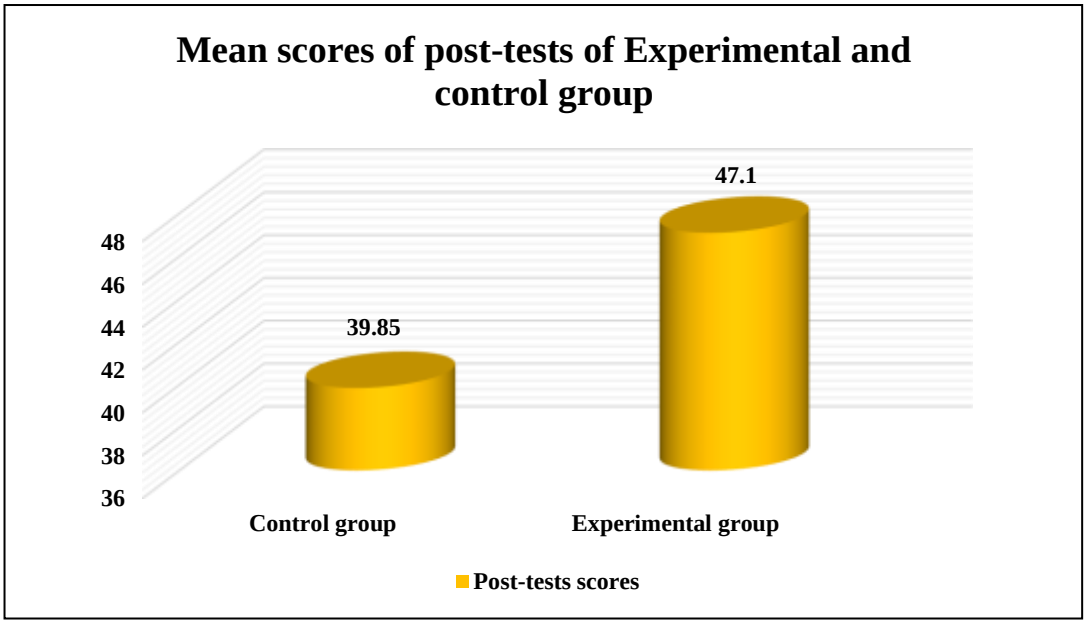
Table 5. *Significance of post-test scores in control and experimental groups of Chemistry e-modules*

Group	No. of students	Mean	SD	t	p-value (at the 0.05 level of significance)

Control Group	20	39.85	4.9	**4.8**	2.01
Experimental group	20	47.1	4.7		

The obtained "t" value is 4.8, which is more than the p-value at the 0.05 level (P<0.05), so null hypothesis 4 is rejected. This result showed that mean between the post-test scores of students was significantly higher in their achievement. This was due to attribute to the treatment received by the experimental group increasing its achievement in comparison to the control group, which did not carry any treatment.

Figure 7. *Graphical representation of the "Post-test scores in Experimental and Control groups."*



Discussion and Results

As the study was accomplished in two phases, and the first objective of the study was accomplished through the development phase. It is apt to discuss the results of the first objective. The study highlights that the design of the courseware could draw the attention of the learners and keep them actively engaged during the implementation of the e-modules of Chemistry. The multimedia components of text, audio, and images could be effectively integrated into the modules. Learning objectives related to the development of e-content in Chemistry are achievable. ADDIE model of instructional design can be adapted successfully for the development of qualitative e-content. All the sub-processes and processes "Analysis, Design, Development, Implementation, and

Evaluation" of each step of ADDIE can be effectively implemented to develop quality e-content. A teacher can also develop an e-Content of his/her own by following the steps of development of the e-content of the study. The storyboard is meticulously developed with details of each screen. Website designing can also be done by the teachers as instructional designers.

The second objective of the study was achieved through a quantitative experimental study. The results reveal that the e-modules developed are effective for enhancing learning achievement in chemistry for students of secondary level. There has been a significant increase in post-experimental data showing the effect of e-modules on the achievement of the students. To establish the effectiveness of the e-modules, there has been a pre-test comparison of control and experimental groups, which showed a nearly equal level of achievement between groups in the beginning, but their post-test comparison showed a significant difference between the control and experimental groups. So, it can be determined assuredly that e-modules of Chemistry are effective in positively influencing the achievement of pupils of the science of secondary level.

Conclusion

In the light of the research findings, the research work may contribute to alleviating the difficulties of science learners on specific topics of Chemistry through the use of freely available e-content. The website www.learning-afresh.com launches e-content on Chemistry and provides easily available notes on the topics with a quick assessment of learners' learning at the end of each e-module. The study also ushers the path for teachers to practice the e-content development process. The study details each process and sub-process of instructional design that refers to the ADDIE model. The website devoted to the study can help in improving the teaching-learning scenario.

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