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Effect of E-Module on Academic Achievement of Students In Chemistry at Secondary Level: A Meta-Analysis

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Abstract: The objective of this study is to examine the effect of e-module on the academic achievement of students in chemistry at the secondary level. The reviewer preferred to do a meta-analysis rather traditional literature review as it is a scientific process and provides strong evidence about the effectiveness of any intervention. To meet the objective of this study, the reviewer analyzed experimental studies accessed through different databases like Semantic Scholar, Eric, Zendy and Science Direct and research repositories like Google Scholar and Research Gate. To search relevant studies, the reviewer used keywords like e-module, electronic module, academic achievement and educational outcomes. By using these keywords, 60 publications were accessed that used experimental design. These studies were from 2016-2024. After the removal of duplication and not open access, 25 studies were identified. Out of 25 publications, 20 studies have met the inclusion criteria. After full screening, 8 studies were selected for systematic review. Finally, 2 studies that had no mean and standard deviation values of control and experimental groups, were eliminated. Meta-analysis was done on 6 studies. The reviewer used Jamovi 2.3.28 software to do data analysis. Cohen's d and Sampling variance of all studies were calculated. The heterogeneity and publication bias of all studies were checked before conducting the main analysis. On the base of the heterogeneity test, a random effect model was used to calculate the combined effect of studies. The forest plot showed a large effect size that concluded that e-module has a strong effect on the academic achievement of students in chemistry at the secondary level.

Keywords: E-Module, Academic Achievement, Chemistry, Secondary Level

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Introduction

Education is considered as a pouring of empirical facts traditionally without any effective learning in which the teacher acts like authority and ignores the multi-dimensional growth of children. Education is a process to improve the quality of human beings and improves their personality, skills and intelligence by providing a learning atmosphere. Learning is not always according to expectations because students are not fully involved in the learning process. There should be active involvement of learners in the learning process for successful learning (Linda & Nufus, 2020).

The pattern of education has changed with the progress of time, and the paradigm has greatly shifted from conventional teaching to innovative teaching and now it has become our need because innovative teaching enhances the efficiency and richness of learning (Serdyukov, 2017). Now, different innovative teaching methods are used to enhance learning. These are interactive videos, simulations, digital modules and different games. In this era of information and communication technology, people become more innovative, critical and creative in the teaching and learning process with the use of technology (Ala-Mutka, Punie, & Redecker, 2008). There are a lot of ICT devices that

are used to facilitate the teaching and learning process and provide innovative learning environments such as e-learning.

E-learning is an innovative learning environment that makes the content interesting by shifting it to ICT devices. It is a way of learning with the help of the internet, interactive ICT tools and audio and video tapes that improves the teaching and learning process by providing the opportunity to revise content easily as it is not interesting to revise printed material. It helps the teachers to plan content effectively according to individual differences of students and they are easily tailor their experiences to meet the specific objectives (Suresh et al., 2018).

Chemistry subject revolves around matter and especially atoms which is an abstract concept so many students find this subject difficult. There are a lot of abstract concepts in Chemistry like chemical equations, mole, concentration, hydrolysis and chemical formulas which are important to grasp by students for a deep understanding of this subject. Abstract concepts of chemistry are difficult to understand for students as there is a mixture of concepts that can be microscopic as well as macroscopic (Sirhan, 2007). Due to the high conceptual nature of chemistry, it is difficult to understand its concepts through rote learning. Research has shown that students have misconceptions about chemistry concepts throughout the degree level. It is important to give conceptual understanding to the students as all teaching does not always result in learning. To reduce the complexity of chemistry, various teaching methods are used for secondary classes, and these are project method and laboratory method etc.

Literature has clarified that the removal of misconceptions in chemistry is difficult to address if innovative strategies are not used to cover the curriculum (Moyo, 2018). Abstract concepts of chemistry are difficult to set up in the minds of learners which leads to misconceptions, so the interactive method helps to identify them and remove these misconceptions of learners during learning (Cakir, 2017).

Successful learning needs innovative and effective teaching tools to improve the abstract concepts of students regarding science subjects, especially by providing a concrete understanding of chemistry. Different instructional materials can be used as pedagogical tools. Instructional material is the most important tool in the teaching process. It is usually in the form of textbooks sponsored by the Government and different key books traditionally. There was less use of technology to enhance the conceptual understanding of students in class (Putri & Aznam, 2019).

Module is a good and effective example of a pedagogical tool that helps the students to shift their ideas and thoughts impressively by arousing their interests, curiosity and willingness to learn and also gives free time to teachers so they can do more work on the emotional, mental and psychological development of learners. Module can be in printed as well as digital form. The digital form of the module is more attractive and modern as compared to the printed form as it provides the facility to navigate between videos, sounds and animations easily with a lot of quizzes and automatic feedback (Serevina et al., 2018). E-module is a systematically arranged material which provides flexibility according to age and level of students. It can be used as a pedagogical tool to provide efficient, flexible, independent and planned way to learn. It helps the student in learning and understanding the concepts effectively (Qamar et al., 2023).

E-modules are used on electronic platforms. Students remain active during learning with e-module because they are in direct link with interactive and innovative content (Cannarelli et al., 2016). E-module is an emerging application of E-learning and is in digital form which is extensively used for learning environments to enhance cognition and students can effectively take any concept. It demands that the learners can learn any concept with fun as we know that e-module is an interactive material in a systematic arrangement that is used in the learning process according to the age, interest and level of learners. Teachers can use this digital module as a teaching tool to give an effective, independent, interesting, planned and efficient way to learn and complex concepts understandably better (Linda & Nufus, 2020). These modules give proof of the quality of learning and enhance critical and high-order thinking among students.

In the 21st century, there is a flood of information from which selecting necessary information and designing suitable strategies are important skills for effective learning. These skills are necessary to learn especially with the use

of ICT to create a healthy educational environment. With the involvement of ICT in the educational process, use of the most recent innovative technology is inevitable. Literature has shown that e-module has a strong relationship to the academic achievement of students (Syahroni et al., 2016). With the use of an E-module, teachers can identify the needs of students in learning, map out their goals, select and apply suitable learning strategies for the enhancement of knowledge and evaluate them through in-time feedback (Alsancak Sirkaya & Ozdemir, 2018).

E-module helps students to enhance the learning process through the concrete understanding of abstract concepts, arousing student's interest and critical thinking that increases academic achievement of students (Lamb & Annetta, 2013). According to Abdullah and Mirza (2019), academic achievement is a source to get knowledge about the goals of education that are required to be achieved by students in a fixed time. We can measure these goals usually in the form of scores with the help of different tests and assessments. Studies have shown that e-module helps the students to understand the science concepts in a better way and their academic performance increases (Qamar et al., 2022).

The reviewer tried to conduct a meta-analysis on this topic to reveal the effect of e-module on the academic achievement of students in chemistry at the secondary level. Findings of different studies provide scientific proof of the fact that e-module has a positive or negative effect on the academic achievement of students at the secondary level. So, the objective of this study is to examine the effect of e-module on the academic achievement of students in chemistry at the secondary level in comparison to the traditional method of teaching with the help of meta-analysis by considering different publications.

Research Question

The current study is seeking the answer to the following research questions.

1. What is the effect of e-module on the academic achievement of students in chemistry at the secondary level?

Methodology

Research Method

This is meta-analysis research. It has been conducted to analyze the previous studies on this topic through systematic review. Data was collected and analyzed with the help of statistics. Different steps were carried out to conduct a meta-analysis. These are the search for literature, selection of inclusion and exclusion criteria, and data coding, evaluation of each study, data analysis and interpretation.

Study Selection Process

To conduct a meta-analysis, different studies were selected from published articles in scientific journals and different theses. Reviewer has made sure that these studies have proper statistical analysis data. These studies were retrieved from different databases like Semantic Scholar, Eric, Zendy and Science Direct by using different keywords like "e-module, electronic module, technology base module, academic achievement and educational outcomes. Moreover, research repositories and online libraries like Google Scholar and Research Gate were also used.

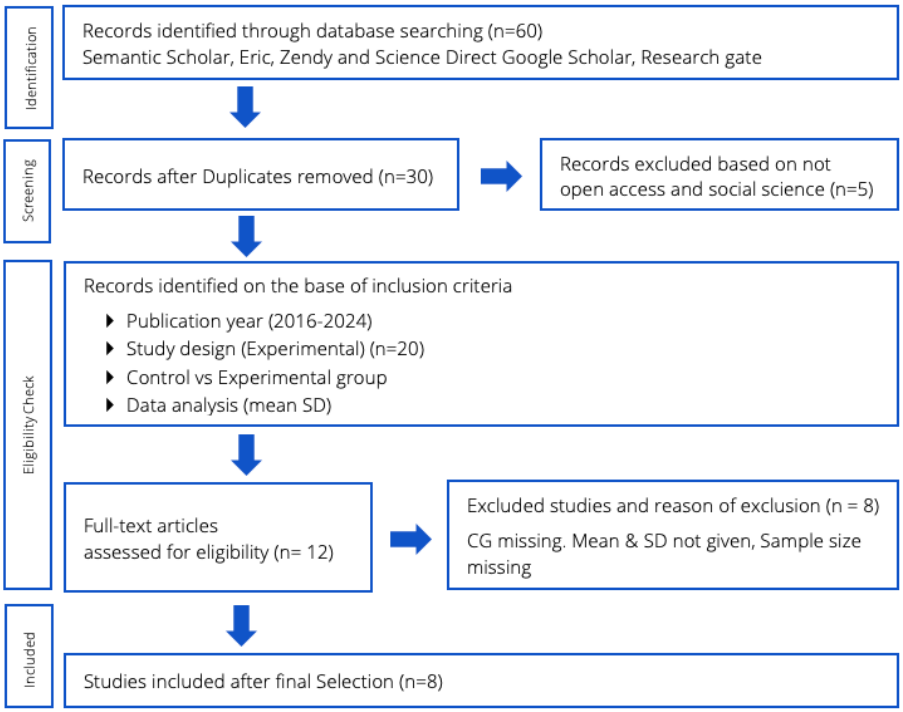
In the first step, the reviewer read the abstracts of the studies and duplicate studies were eliminated. Some were rejected due to limited access. After this phase, 60 studies were selected for analysis. Inclusion and exclusion criteria were defined on the base of which, further selection of studies has been done.

Selection of Inclusion-Exclusion Criteria

The reviewer has defined inclusion and exclusion criteria for the selection of studies by using the PRISMA framework. This included Publication year (2016-2024), Publication type (articles, conference papers and theses), Language (English), Population (Secondary level), Study design (Experimental), Experimental and control groups identified, Data analysis (Mean, SD), Search equation ("E-module" OR "Electronic module" OR "Technology base module").

Figure I

Inclusion-Exclusion Criteria



Comprehensive Literature Search

The reviewers identified relevant studies by using multiple databases, different sources and databases and did a comprehensive literature search for meta-analysis. Researcher has used the following sources:

Academic databases (Semantic Scholar, Eric, Zendy and Science Direct), Repositories and Online libraries (Google Scholar and Research Gate), Grey literature (Theses and reports), Hand-searching by using the reference list

Use Keywords and Specific Search Terms

Next step was to develop a search strategy by using specific search terms, keywords and synonyms to focus on research questions. Keywords were included:

E-module, electronic module, technology base module, Secondary level and Academic achievement and educational outcomes

Initial Screening Process

In this step, reviewers reviewed the title and abstract of each study to clarify whether this study is according to inclusion criteria or not. During the screening, following things are considered:

Relevance to research questions, Title of publication, Methodology used, Population and outcomes.

Full-text Screening

Studies that have been selected after the initial screening criteria were retrieved and revised through full-text screening. Things to be considered for full-text screening include:

Quality of study, Risk of Biasness, Methodological rigor and Relatedness to research questions.

Data Extraction

Reviewers extracted data from each selected study. This relevant data extraction includes:

Characteristics of study (author, publication year and design of study), Methodology (Sample size and data collection and analysis) and Outcomes.

Table 1

Data Extraction

Study ID	Type	Author	Language	Year
Study 1	Article	Alsancak Sirakaya et al.	English	2018
Study 2	Article	Sarikhani et al.	English	2016
Study 3	Article	Njoku et al.	English	2021
Study 4	Article	Hussain et al.	English	2023
Study 5	Article	Kuit et al.	English	2021
Study 6	Article	Lapawi et al.	English	2020
Study 7	Article	Suleman et al.	English	2017
Study 8	Article	Winatha et al.	English	2018

Table I: This table showed the information about selected studies as a result of a systematic review. It showed that language of all studies were English and studies included thesis and articles.

Table 2

Data Extraction

Sr. No	Author	Year	Study Design	Data analysis
1	Alsancak Sirakaya et al.	2018	Quasi-Experimental	T-test, ANOVA
2	Sarikhani et al.	2016	Pretest/Posttest Experimental	T-test (Mean, SD)
3	Njoku et al.	2021	Quasi-Experimental	Mean, SD, ANCOVA
4	Hussain et al.	2023	Quasi-Experimental	T-test (Mean, SD)
5	Lapawi et al.	2020	Quasi-Experimental	T-test (Mean, SD)
6	Suleman et al.	2017	Pretest/Posttest Experimental	T-test (Mean, SD)
7	Winatha et al.	2018	Pre Experimental	T-test (Mean, SD)

This table also shows the extraction of studies. These studies were experimental. Most studies were Quasi-Experimental. Data was analyzed through t-test in these studies.

Quality Assessment of Selected Study

Quality of each study was assessed by using different tools like Cochrane assessment tools to ensure quality appraisal. An in-depth review was conducted and check the study limitations and risk of bias.

Finalize Study Selection

After completing all steps, studies were finalized to conduct the systematic literature review. A comprehensive study selection process was carried out to follow all these steps (Booth et al., 2019).

Coding of Data

Reviewer developed coding of data to ensure inter-coder reliability before data analysis. On the base of inter-coder reliability, 6 out of 8 studies were selected for data analysis.

Data Analysis

The reviewer selected 6 studies for data analysis. Sample size, Mean, SD were noted and then Cohen's d value was calculated. Sample size and Cohen's d value of the experimental and control group of each study were added in Jamovi Software. Hedge's g value of each study was calculated. Heterogeneity value was calculated to decide about the model (fixed effect or random effect model).

Table 3

Heterogeneity Statistics

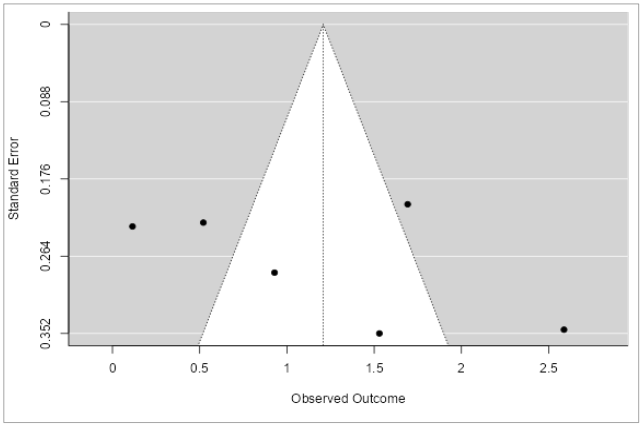
Tau	Tau^2	I^2	H^2	R^2	df	Q	p
3.351	11.2289 (SE= 7.2825)	99.11%	112.129	.	5.000	115.626	<.001

This table shows that the heterogeneity test was highly significant. So, a random effect model was suggested to calculate the overall effect size. The random effect model was used based on information from the heterogeneity test.

Possible publication bias was checked before the main data analyses. Several methods can be used. A funnel plot was used to check publication bias.

Figure 2

Funnel Plot



The shape of funnel plot was ideally sharp that indicated that studies are close to symmetry but not exactly symmetric. Narrow top of the funnel showed that there is no bias and precision is high. To make further decisions about publication bias, an asymmetry test was conducted.

Table 4

Publication Bias Assessment

Test Name	Value	p
Fail-Safe N	284.000	< .001
Begg and Mazumdar Rank Correlation	0.867	0.017
Egger's Regression	8.916	< .001
Trim and Fill Number of Studies	0.000	.

Egger's Regression test value was 8.916 and p-value was less than 0.05 means there was publication bias.

Results

The results of 6 out of 8 studies were analyzed through meta-analysis. Information about all studies i.e. Sample size, Mean, SD of control and experimental group and Cohen's d value were presented in Table.

Table 5

Control and Experimental Group Information From all Publications

Author	Year	NT	M(T)	SDT	NC	M(C)	SDC	Cohen's d	SE
Alsancak Sirakaya et al.	2018	32	79.41	64	34	72.04	64	0.115	0.053
Sarikhani et al.	2016	20	13.50	1.48	20	7	1.35	2.588	0.121
Hussain et al.	2023	30	71.07	9.98	30	62.20	9.08	0.929	0.080
Kuit et al.	2021	30	20.50	5.625	49	17.53	5.767	0.521	0.051
Lapawi et al.	2020	36	45.82	9.98	31	31.38	6.78	1.692	0.042
Suleman et al.	2017	20	92.15	2.72	20	68.9	2.12	1.530	0.124

As shown in Table 5, study conducted by Kuit et al. (2021) has the largest sample size and studies conducted by Sarikhani et al. (2016) and Suleman et al. (2017) have the lowest sample size among studies. A random effect model was used to calculate the overall effect size. The results of this model are presented in Table 6.

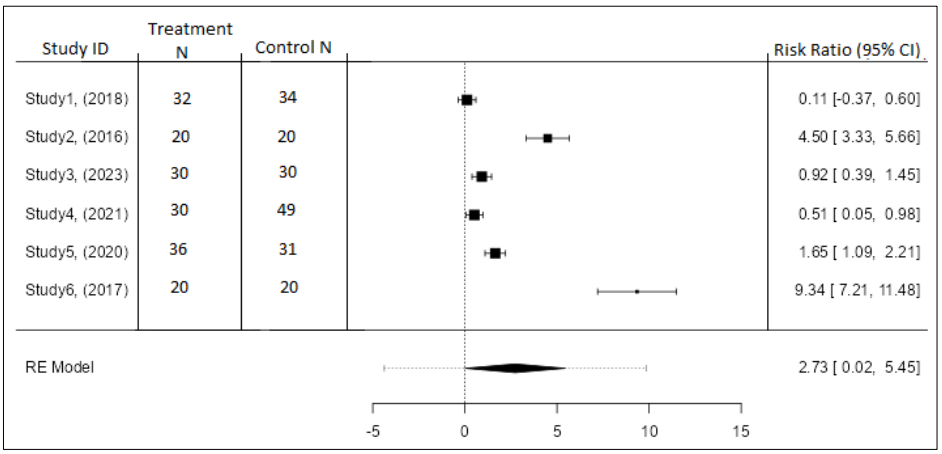
Table 6

Random Effect Model

Random-Effects Model (k = 6)						
	Estimate	Se	Z	p	CI Lower Bound	CI Upper Bound
Intercept	2.73	1.39	1.97	0.049	0.017	5.448

Figure 3

Forest Plot



The overall effect size value was 2.73 and it was significant (se= 1.39, p = 0.04). The lower limit was 0.017 and the upper limit was 5.44. As the p-value is smaller than significant value (α = 0.05) showed that treatment has a positive effect. Forest plot was examined and it also showed that e-module has a positive effect on academic achievement of students in chemistry.

Discussion

This study focuses on examining the effect of e-module on the academic achievement of students in chemistry at the secondary level through meta-analysis. The reviewer calculated the overall effect size of studies and tried to prove that e-module has a positive effect on students' academic achievement. The results of this study are important for examining the effect of e-module in various studies. A meta-analysis of 6 studies was conducted and the forest plot showed that the use of e-module has a large effect on the academic achievement of students. When teachers use traditional teaching methods in science subjects then students become de-motivated, and their learning is affected badly. Use of technology-based modules during teaching, students become motivated, and their learning become enhanced.

Conclusion

In this study, a meta-analysis method was used to find the overall effect size of the findings of different studies to examine the effect of e-module on the academic achievement of students in chemistry at the secondary level. It was concluded on the base of findings that e-module can be used as an alternative teaching method to increase learning outcomes and academic achievement of chemistry students.

E-module has the power to engage the students with individual differences and can tackle their multiple senses due to a variety of components like video, images, audio and textual material. Different interactive components of e-module created motivation, readiness and interest among students and students of the experimental group were enthusiastic to learn as compared to the control group which affected their scores.

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