CHAPTER 2

REVIEW OF RELATED LITERATURE

2.0 INTRODUCTION

The review of related literature is the process of thoroughly investigating previous studies on the intended study. Through the review of related literature, investigators try to find out the research gaps or areas that were not investigated or remained as the thrust area. It helps the researcher frame the research question and gives insight to the researcher on why and how to investigate the intended study. The researcher has reviewed a total of ninety-one studies from different databases like SCOPUS, Elsevier Science, Education Resources Information Centre (ERIC), Taylor and Francis, and Doctoral Dissertations. The literature review for the present study is classified into three sections:

2.1 Reviews on the Strategy Developed on Constructivism

2.2 Reviews on Cognitive Load

2.3 Reviews on Innovation in the Lecture Method

2.1 REVIEWS ON STRATEGY DEVELOPED ON CONSTRUCTIVISM

Gatlin (1998) conducted a study to compare the effectiveness of two types of pedagogy: didactic/traditional and constructivist-informed pedagogy on student achievement. Secondly, this study examined the relationship between students' and teachers' perceptions of constructivism in classroom environments. A non-equivalent control group pretest-post-test and delayed post-test quasi-experimental design was used in this study. The sample of the secondary students was drawn using the purposive sampling method. Subjects in this study included two teachers and their respective students from a suburban public school district in the South. The sample consisted of two groups, one taught by traditional/didactic instruction (n = 25) and the other taught by constructivist-informed pedagogy (n = 26). Data for this study was collected using the Constructivist Learning Environmental Survey, The Science Classroom Observation Rubric, the Teaching Practices Assessment, and a demographic survey. Ancillary data was collected using the Student Outcome Assessment and interpretive methodologies. The analysis of covariance (ANCOVA) was used to measure the effects of constructivist-informed and traditional pedagogy on student achievement. Student achievement was measured with a researcher-

designed pretest, post-test, and delayed post-test. A significant difference was found in the science achievement post-test, where the students receiving the traditional pedagogy scored higher than those taught by the constructivist pedagogy. However, the scores of students receiving constructivist-informed pedagogy showed a slight increase on the delayed post-test, while the traditionally taught students' scores decreased. Thus, the difference in the achievement of the two groups was diminished over time. A repeated measures ANOVA was used to analyze the ancillary data from the Student Outcome Assessment. ($p < .05$) Among 51 students tested, those who received the constructivist informed pedagogy had higher retention, approaching the significance of the biology concepts tested over time. Ancillary data was used to assist in the interpretation of the assessment measurements. Using ratios of students' and teachers' scores of perceived constructivist attributes in their classroom appeared to be an effective way for teachers to compare student perceptions with their own.

Williams (1999) examined the effects of mind mapping, a brain-based learning strategy, on adult accomplishment while accounting for learning styles and brain hemisphericity. 112 participants in the study received two days of mind-mapping training from the same licensed mind-mapping instructor in a corporate training environment. In this study, the quasi-experimental pre-test post-test design has been adopted by the researcher. Two groups of subjects were created: an experimental group and a control group. The control group completed an accomplishment assessment test before learning how to use mind mapping to gauge comprehension of a reading chapter while taking traditional notes. Following two days of mind mapping instruction, the same accomplishment assessment test was administered to the experimental group. Rather than taking notes, the experiment group's participants were instructed to mind map the information in the reading passage. Data were analyzed by t-test and ANOVA. The outcomes showed that both groups succeeded to the same degree.

Huseyin et al. (2003) conducted a study to investigate the effectiveness of instruction based on the constructivist approach over traditional instruction on 10th-grade students' understanding of chemical equilibrium concepts and to identify misconceptions concerning chemical equilibrium concepts. The subjects of this study consisted of 71 10th-grade students from two chemistry classes of the same teacher. The experimental control group design was used to investigate this study. Each

teaching strategy was randomly assigned to one class. The data were obtained from 32 students in the experimental group taught with instruction informed by the constructivist approach and 39 students in the control group taught with traditional instruction. The data were analyzed using the statistical test ANCOVA. The results indicated that the students who used the constructivist principles-oriented instruction earned significantly higher scores than those taught by traditional instruction in terms of achievement related to chemical equilibrium concepts.

Becker and Maunsaiyat (2004) conducted a study on comparison of students' achievement and attitudes between constructivist and traditional classroom environments in Thailand vocational electronics. The objectives of this quasi-experimental study were: 1. To determine if there was a difference in knowledge achievement between Thailand's vocational students instructed using constructivist instruction (with open-ended dialogue, problem-based learning, and cooperative learning) and using traditional instruction (with lectures, directed demonstrations, and scripted experiments). 2. To identify whether Thai vocational students preferred instruction modeled upon constructivist philosophy rather than traditional instructional philosophy. The target population consisted of students participating in electronics courses. The sample comprised students who attended the Electronics Measurement and Instrument course at two selected technical colleges in central Thailand. Two intact classes at each college received both treatments (counterbalanced design). There were 108 students used as the sample in the study. An effect size and an ANCOVA were used to test the first objective. There was no statistical difference between the achievement scores of the students receiving constructivist instruction and those receiving traditionally instructed students. However, the constructivist-instructed students had higher scores on the post-test and the delayed post-test compared to those of the traditionally instructed students. The sample mean scores, standard deviation, percentages, and opinions on surveys were used to compare results for the second objective. The findings showed that there was a significant difference in student preferences. Students preferred constructivist instruction.

Donaldson (2004) conducted a study to assess the effectiveness of the Constructing Physics Understanding (CPU) pedagogy on middle school students' learning of force and motion concepts. This study explores the effectiveness of the Constructing

Physics Understanding (CPU) pedagogy versus traditional instruction for teaching middle school students Newtonian force and motion concepts. Students from 16 seventh-grade classrooms (n = 358) were selected for this study based on three criteria: (a) each regular education classroom taught force and motion concepts as required by the district curriculum; (b) each classroom teacher was identified by the school principal as being an exemplary teacher; and (c) the teachers were self-reported as either using a constructivist CPU pedagogy (8 classrooms) or a non-CPU, more traditional pedagogy (8 classrooms). To control for teacher adherence to instructional method (CPU vs. non-CPU), each teacher was randomly observed and rated by three independent raters on the Reformed Teaching Observation Protocol (RTOP) instrument. Descriptive statistics showed that the self-reported CPU teachers scored a higher mean in each section of the RTOP indicating that the CPU teachers, as rated by the observers, used a more constructivist approach to teaching force and motion to their students than the non-CPU teachers. Students were pre- and post-tested on a 20-item force and motion conceptual test covering concepts in motion, Newton's 1st Law, Newton's 2nd Law, and Newton's 3rd Law. Hypothesis testing was conducted using repeated measures ANOVA to further analyze the interaction between teaching method (CPU vs. Non-CPU) and force and motion knowledge gain. Results showed significantly higher gains for the CPU group in total score ($p < 0.001$), kinematics and motion questions ($p < 0.001$), and Newton's Third Law questions ($p < 0.05$). This significant difference indicates that the knowledge gain for students taught with the CPU pedagogy was greater than the knowledge gain for students taught with the more traditional, non-CPU pedagogy in the areas of motion and Newton's Third Law. Results for questions on Newton's First and Second Laws showed higher post means in the CPU group; however, the gains were not significant ($p > 0.05$) indicating very little difference between the CPU and non-CPU groups in students' knowledge gain in these areas.

Kroesbergen et. al. (2004) compared the effects of small-group constructivist and explicit mathematics instruction in basic multiplication on low-achieving students' performance and motivation under the topic Effectiveness of Explicit and Constructivist Mathematics Instruction for Low-Achieving Students in the Netherlands. A total of 265 students (aged 8-11 years) from 13 general and 11 special elementary schools for students with learning and behaviour disorders participated in

the study. In this study there was 2 experimental groups were formed. The experimental groups received 30 minutes of constructivist or explicit instruction in groups of 5 students twice weekly for 5 months. Pre-tests and post-tests were conducted to compare the effects of students' automaticity, problem-solving, strategy use, and motivation on the performance of a control group who followed the regular curriculum. Results showed that the math performance of students in the explicit instruction condition improved significantly more than that of students in the constructivist condition, and the performance of students in both experimental conditions improved significantly more than that of students in the control condition. Only a few effects on motivation were found. We, therefore, concluded that recent reforms in mathematics instruction requiring students to construct their knowledge may not be effective for low-achieving students.

Puacharearn and Fisher (2004) studied "The Effectiveness of Constructivist Teaching on Improving Learning Environments in Thai Secondary School Science Classrooms". The overall aim of this research study was to determine whether teachers can use cooperative learning integrated with constructivist teaching through an action research process to improve their classroom environments. This study attempted to answer the following three research questions: 1. Is the Constructivist Learning Environment Survey (CLES) a valid and reliable questionnaire for use in Thailand? 2. What are the students' perceptions of their actual and preferred learning environment from a constructivist perspective? 3. Are teachers able to make use of cooperative learning integrated with learners' responses to the CLES to improve their classroom learning environments? 4. Does cooperative learning integrated with constructivist teaching improve students' attitudes towards science learning activities and self-efficacy? Survey, interview, observation, and case study methods have been used by researchers at different stages of the study. The sample of this study is 606 students of the upper secondary class of Nakornsawan province of Thailand. One-way ANOVA has been used for analyzing the collected data. He found that the CLES questionnaire which was proven to be valid and reliable for use in Thailand could be used by Thai science teachers and researchers to conduct further investigations leading to improvements in science classroom environments and consequently students' achievement in science. Teachers can make use of cooperative learning integrated with learners' responses to the CLES to improve their classroom learning

environments. Changes in classrooms did occur, thus supporting the effectiveness of cooperative learning integrated with constructivist teaching in improving learning environments and students' attitudes toward science in Thailand.

Liang and Gabel (2005) examined the effectiveness of a new constructivist curriculum model in improving prospective teachers' understanding of science concepts, fostering a learning environment supporting conceptual understanding, and promoting positive attitudes toward learning and teaching science and chemistry under the topic Effectiveness of a constructivist Approach to Science Instruction for Prospective Elementary Teachers. A non-equivalent pretest–post-test control-group design was employed. The sample of this study was the study involved three instructors and 121 students who enrolled in six respective sections of an introductory science course at a large mid-western university. ANCOVA and repeated measures ANOVA were used to analyze the scores on concept tests and attitude surveys. Data from videotaped observations of laboratory sessions and interviews of prospective teachers were analyzed by employing a naturalistic inquiry method to provide insights into the process of science learning and teaching for the teacher trainees. Results revealed there is no statistically significant difference found for prospective elementary teachers' understanding of the target science concepts and prospective elementary teachers' attitudes toward science and chemistry but the result shows a better learning environment in PIPS class (constructivist method).

Cunningham & Edge (2006) conducted a study to know the effect of mind mapping on student achievement in high school biology. The purpose of this study was to determine if achievement in high school science courses could be enhanced by utilizing mind mapping. The subjects were primarily 9th and 10th graders (n = 147) at a suburban South Texas high school. A pre-test-post-test control group design was selected to determine the effects of mind mapping on student achievement as measured by a teacher-developed, panel-validated instrument. Follow-up interviews were conducted with the teacher and a purposive sample of students (n = 7) to determine their perceptions of mind mapping and its effects on teaching and learning. An independent samples t-test and a one-way analysis of covariance (ANCOVA) determined no significant difference in achievement between the groups. The experimental group improved in achievement at least as much as the control group.

Mind-mapping has affective value as a teaching and learning strategy, as indicated by the follow-up interview data.

Loyens et. al. (2006) studied 'Student's Conceptions of Constructivist Learning: A Comparison between a Traditional and a Problem-based Learning Curriculum'. This study investigated students' conceptions of constructivist learning activities in problem-based learning (PBL) and a traditional curriculum. Participants were 186 undergraduate first-year students enrolled in a PBL psychology curriculum and 107 undergraduate first-year psychology students in a lecture-based curriculum. The researcher examined whether students who have chosen a problem-based curriculum have different conceptions of constructivist assumptions compared to students who have chosen to be enrolled in a traditional, lecture-based curriculum when they enter university. Although constructivism represents an influential view of learning, studies investigating how students conceptualize this perspective have not been conducted before. A structural equation modelling approach was adopted to test the hypothesized model in both student populations and to calculate latent means. Results suggested that students in the PBL environment agree more on constructivist assumptions of cooperative learning and the use of authentic problems, while students in the traditional curriculum acknowledge the importance of motivation to learn more.

Beena (2008) contrasted the efficiency of teaching mathematics using the mind-mapping methodology with the conventional method. The study set out to evaluate the mind map method's utility and validate the advantages of using it as a memory aid. The sample consists of fifty eighth-grade students with the help of purposive sampling. Both a teacher questionnaire and a student evaluation scale were used to assess the value of mind maps for mathematical learning. Mann-Whitney-U test was used to analyze the data. The results showed that teaching eighth-grade student's mathematics with a mind map is more successful than teaching them with a traditional method. Additionally, it has been found that teaching with mind maps increases the significance of learning.

Dobbs (2008) Compared student achievement in the problem-based learning classroom and traditional teaching methods classroom. The purpose of this study was to determine whether the teaching strategy, Problem-Based Learning (PBL), will improve student achievement in high school chemistry to a greater degree than

traditional teaching methods. The research question looked at whether there was a difference in student achievement between students in a high school chemistry classroom using PBL and students in a classroom using traditional teaching methods. The sample of this study was comprised of secondary school students. The purposive sampling technique was used to draw the sample from the population. In the present study, a quasi-experimental pretest/post-test control group design has been used by the researcher. The Achievement of the students of both groups was assessed by scores on a 20-question quiz. An independent samples t-test compared gains scores between the pretest and post-test. Analysis of quiz scores indicated that there was not a significant difference ($t(171) = 1.001$, $p = .318$) in student achievement between the teaching methods. Because there was not a significant difference, each teacher could decide which teaching method best suited the subject matter and the learning styles of the students. This study adds research-based data to help teachers and schools choose one teaching method over another so that students may gain knowledge, and develop problem-solving skills, and life-long learning skills that will bring about social change in the form of a higher quality of life for the students and community.

Nong et al. (2009) investigated a study in Vietnam. The study aimed to ascertain how students' academic progress in teaching and learning psychology was impacted by digital mind mapping as contrasted to paper-based mind mapping and conventional teaching approaches. The sample of the study was Ninety first-year students at the Thai Nguyen Teacher Training Institute in Vietnam. The study involved the random assignment of participants to three groups: the experimental group, which received instruction through digital mind mapping, the control group 1 (which received traditional instruction), and the control group 2 (which received conventional instruction using paper-based mind mapping). t-test and ANOVA were used to analyze the data. The results showed that students' academic achievement significantly improves when they use the computer-based mind mapping method to study psychology.

Abi-El-Mona and Adb-El-Khalick (2010) conducted a study on 62 eighth-grade pupils. The purpose of the study was to find out how mind maps helped students achieve more in science if this influence was influenced by their past academic success, and what connection there was between the conceptual knowledge of the students and their mind maps. Participants in an eighth-grade science classroom were

split into control and experimental groups in four intact portions. The quasi-experimental pre-test and post-test design was used in this study. A multiple-choice exam was utilized to evaluate the improvement of the students in two categories after the treatment. T-test and ANOVA were used to compare the groups. The findings demonstrated that compared to the pupils in the comparison group, the experimental group's improvements were statistically significant and considerably greater.

Seyihoglu and Kartal (2010) investigated a study with the aim of to reveal the opening of educators regarding the application of the mind mapping method in Life Science and Social Studies classes, as examined by X in 2010. Twenty primary education instructors are included in the project. A semi-structured interviewing method was employed in this investigation. The teachers' opinions served as the basis for defining the themes and codes for the content analysis. The results showed that the teachers' proficiency in the constructivist approach portions of the lesson was lacking, which is why it was observed that they only applied the mind mapping technique to the introduction and evaluation phases of the lessons. Teachers believe that using the mind mapping technique to lecture instruction would be more appropriate. Among the benefits of this strategy are those that provide students with permanence in their learning and increase their exam achievement; among the drawbacks are those that may arise due to time constraints.

Vaca (2010) conducted a study to know the Effect of constructivist strategies on the science test scores of middle school students. The purpose of this quasi-experimental quantitative study using a pretest/post-test control group design was to examine how the use of a hands-on, constructivist teaching approach with low-achieving eighth-grade science students affected student achievement on the 2007 Ohio Eighth Grade Science Achievement Test post-test (N = 76). The research question asked how using constructivist teaching strategies in the science classroom affected student performance on standardized tests. Two independent samples of 38 students each consisting of low-achieving science students as identified by seventh-grade science scores and scores on the Ohio Eighth Grade Science Half-Length Practice Test pretest were used. Four comparisons were made between the control group receiving traditional classroom instruction and the experimental group receiving constructivist instruction including (a) pretest/post-test standard comparison, (b) comparison of the number of students who passed the post-test, (c) comparison of the six standards

covered on the post-test, (d) post-test's sample means comparison. A Mann-Whitney U Test revealed that there was no significant difference between the independent sample distributions for the control group and the experimental group. These findings contribute to positive social change by investigating science teaching strategies that could be used in eighth-grade science classes to improve student achievement in science.

Dhindsa et al. (2011) investigated a study titled "Constructivist- Visual Mind Map Teaching Approach and the Quality of Students' Cognitive Structures." This study examined how a constructivist-visual mind map teaching approach (CMA) and a traditional teaching approach affected students' perceptions of the degree to which a constructivist learning environment (CLE) was created in their classes, as well as the quality and richness of students' knowledge structures. Six classes, totalling 140 Form 3 pupils aged 13 to 15, were chosen as the study's sample from a typical coeducational Bruneian school. While three other classes—41 boys and 29 girls—used the constructivist-visual mind map teaching approach, enhanced with PowerPoint presentations, three more classes—40 boys and 30 girls—were taught using the traditional teaching approach. Following the magnetism lessons and interventions, the students in both groups were asked to write a summary of what they had learned about magnetism. Flow map analyses were performed on their written descriptions to evaluate the content knowledge and how it was stored in memory as a sign of cognitive organization. A constructivist learning environment survey that was issued was used to gauge the scope of the constructivist learning environment. Data was analyzed by the t-test. The findings demonstrated that compared to traditional teaching approach students, the cognitive structures of constructivist-visual mind map teaching approach students were larger, more thematically structured, and more richly interwoven. Additionally, compared to their peers, constructivist-visual mind map teaching approach students thought that their classroom had a more constructivist learning environment.

Foster (2011) conducted a study titled Comparison of Student Achievement using Didactic, inquiry-based, and the Combination of Two Approaches to Science Instruction. The research problem addressed whether incorporating the two approaches covered the learning requirements of all students in science classes, enabling them to meet state and national standards. The purpose of this quasi-

experimental, post-test design research study was to determine if student learning and achievement in high school biology classes differed for each type of instructional method. Constructivist theory suggests that each learner creates knowledge over time because of the learners' interactions with the environment. The optimal teaching method, didactic (teacher-directed), inquiry-based, or a combination of two approaches instructional method, becomes essential if students are to discover ways to learn information. The research question examined which form of instruction had a significant effect on student achievement in biology. The data analysis consisted of a single-factor, independent-measures analysis of variance (ANOVA) that tested the hypotheses of the research study. Locally, the results indicated greater and statistically significant differences in standardized laboratory scores for students who were taught using the combination of two approaches. Based on these results, biology instructors will gain new insights into ways of improving the instructional process. Social change may occur as the science curriculum leadership applies the combination of two instructional approaches to improve the acquisition of science concepts by biology students.

James (2011) looked into how a mind mapping teaching strategy affected the chemistry achievement of senior secondary school pupils in the Enugu Education Zone, Nsukku. The sample was drawn with the help of purposive sampling. A total of 194 students participated in the study. The pre-test post-test control group design was used in the present study. Two groups of students were formed: the treatment group and the control group. For five weeks, the treatment group received instruction utilizing a mind mapping technique, whereas the control group received instruction using conventional methods. For the data analysis, t-test and ANOVA was used by the researcher. The findings showed that students' cognitive performance in Chemistry was significantly improved by mind mapping as a teaching strategy. Compared to typical teaching methods, mind mapping is a more effective teaching strategy.

Nail (2011) conducted a study on the effect of inquiry-based science instruction on student understanding. The main purpose of this research was to see if inquiry-based instruction in the science classroom had a significant effect on student understanding and retention of information in a rural school in Virginia. The researcher implemented a four-week, inquiry-based unit on Virginia Sol 6.7, based on the 5 E model of

constructivism to 358 sixth-grade students and compared their post-test gains and delayed post-test scores to a control group consisting of 268 students. The control group received traditional teaching methods. The results for the post-test gains produced a $p = 0.01$. Therefore, there was a significant difference in the experimental group, which received the treatment, when compared to the control group, which did not receive treatment. A t-test was also used to compare the delayed test scores of the experimental group to the control group. The results showed a $p < 0.0001$ when comparing the experimental group, which received the four-week inquiry-based science instruction treatment, to the control, which did not receive the treatment. This t-test showed a very highly significant difference between the experimental group and the control group.

Secken and Alsan (2011) studied 'The effect of constructivist approach on students' understanding of the concepts related to hydrolysis.' The study aimed to investigate the effect of the constructivist approach on students' understanding of the concepts related to hydrolysis subject, comparing the constructivist approach with the traditional teaching method, and determining the differences between student success in the constructivist approach and the traditional teaching method. The sample comprised 100 students. The age average of the students is 18–21. Experimental design has been used in this study by the researcher. The control and the treatment groups have been determined randomly. Traditional teaching applications have been conducted with the control group and constructivist teaching applications have been conducted with the treatment group. The Hydrolysis Concept Test has been administered as a pre-test to control and treatment groups to determine the understanding level of the students related to hydrolyzed concepts. The data has been analyzed by using statistical analysis techniques. The results have manifested that the constructivist teaching applications have contributed to students' understanding of the concepts related to the hydrolysis subject.

Balım (2013) conducted a study titled Use of Technology-assisted Techniques of Mind Mapping and Concept Mapping in Science Education: A Constructivist Study. The Major objective of the study was to investigate the effects of using mind maps and concept maps on students' learning of concepts in science subjects. In this study, the quasi-experimental pre-test post-test control group design has been used by the researcher. The sample of the study was 51 sixth-grade students who were selected by

the purposive sampling technique and divided into two experimental groups and one control group. For the data collection, the research has used open-ended questions and semi-structured interviews. Mann–Whitney U-test was used for independent groups, and the Wilcoxon Z test for dependent groups was used to analyze the data. Findings revealed that the use of mind maps and concept maps in the Science and Technology subject is beneficial in increasing student's participation and motivation as it facilitates students' learning by enabling them to correlate a lot of subjects and concepts.

Bhutto and Chhapra (2013) made an investigation on the topic of Educational Research on "Constructivism" -An Exploratory View. This was a cross-sectional study on the teachers and principals of schools, which was a survey research. The sample of this study is teachers and principals of 26 different private and government schools in the Defence and Clifton, Karachi region. This study has been investigated under objective i.e. 1. To evaluate the analysis of constructivist effects on the system of education. 2. To focus on whether this approach works in our system of education. For the data analysis researcher used ANOVA and regression analysis. The result of this study revealed that the constructivist approach significantly affects the education system and the researcher recommended using constructivism in the classrooms.

Rizi et al. (2013) conducted a study titled The Effect of Using the Brainstorming Method on the Academic Achievement of Students in Grade Five in Tehran Elementary Schools. The present study aimed to examine the effect of the brainstorming teaching method on the educational achievement of grade-five students in the schools of District 7 of the city of Tehran, Iran in the educational year 2010–2011. In order to do so, 60 students were selected via cluster sampling method, and then one class (n=30) was exposed to the independent variable (brainstorming method), while another class (n=30) was administered through the traditional method of giving lectures. At first, a researcher-made pre-test was administered to both groups. After that, the independent variable was applied for 10 sessions after which the researcher-made test was administered again. In order to test the research hypothesis, a t-test was used. The result was indicative of the effect of the brainstorming method, and the difference of means in both groups was significant at <0.001. The results showed that using the brainstorming method had a positive effect on the students' educational achievement.

Bhaskar (2014) conducted a study to know the Effectiveness of the constructivism-based 5Es learning strategy to enhance the acquisition of science process skills. The major objective of the study was to examine the effectiveness of the constructivism-based learning strategy as compared to the traditional instructional programme to promote achievement in science. In this study true experimental design was adopted for this study. The sample of the study was 80 students of class nine standard drawn by simple random sampling. The t-test was applied to analyze the data. Results revealed that the constructivism-based strategy enhances achievement significantly in the science subject.

Ayaz and Sekerci (2015) conducted a meta-analysis study to determine the effects of the constructivist learning approach on students' academic achievement. In this study, Master's thesis, doctoral dissertation, and articles in national and international databases were included which are realized between the years of 2003–2014. In this study total of 53 studies were included. For the analysis of the study meta-analysis of the study effect given by Cohen d is used. The results of this study revealed that the constructivist approach has a significant positive effect on learning, but three studies show the negative impact of constructivism on learning.

Aydisheh and Gharib (2015) studied how constructivist instruction affected students' proficiency in mathematics. Using the cluster random multistage selection technique, 364 girls in the third grade were selected from six high schools in Miandoab, Iran. Each school had two groups: 35 children in the experimental group received 10 sessions of instruction using a constructivist method, and the other 35 students in the control group traditionally received the same instruction. A self-made academic accomplishment questionnaire with 30 questions divided into six categories was used by the researcher to collect data. The t-test was applied to check the effectiveness of the methods. The results showed that constructivist instruction can raise pupils' academic performance.

Blessing and Olufunke (2015) examined the possibility of helping students enhance their academic performance in Physics by utilizing the Mind Mapping and Mastery Learning techniques. Finding the best teaching strategy to improve students' physical education learning outcomes was the aim. A non-equivalent pre-test and post-test control group experimental design was employed in the investigation. A basic random

selection method was used to choose three coeducational secondary schools in the Ikere Local Government Area of Ekiti State, Nigeria. For the investigation, 74 Physics students from three senior secondary schools were included. The study included three groups: the control group (teaching by traditional method), the experimental group 1 (teaching via Mastery learning approach), and the experimental group 2 (teaching through mind mapping approach). Data were analyzed by the t-test. The results showed that whether students were taught using the traditional method, the Mind mapping approach, or the Mastery learning approach, the type of therapy had a significant effect on their academic achievement. Academically, students who were taught using the mastery learning approach did the best, than those who were taught using the traditional method. The students who were taught using the mind-mapping technique performed the best.

Mitra (2015) examined the effect of Mind Mapping on students' Science Achievement test scores using a multi-method research design. The study's model schools were Vidya Bhavan High School in Shivajinagar, Pune, and Sardar Dastur Co-Educational School in Camp, Pune. A sample of 208 eighth-grade students was split into two groups using purposeful sampling: the experimental group (105 students) and the control group (103 students). The pre-test post-test control group design was used to examine the differences between the regular teaching method and the constructivist teaching method of mind mapping. In this study, the concurrent triangulation strategy was used. By using this technique, the researcher was able to collect both qualitative and quantitative data simultaneously. Afterward, the two databases were compared to see whether the two types of data overlapped, differed, or combined. An accomplishment test was used to assess the program's success. After calculating the effect size, it was found that 65.95 percent of students like using mind maps. Data analysis revealed that the mean scores of the experimental group were greater than those of the control group. Moreover, it was shown that a programme based on mind maps was just as beneficial for boys as girls.

Mohapatra and Kumari (2015) conducted a study to explore the constructivist approach that could promote the perception of the nature of biology among higher secondary students under the topic exploring the effectiveness of the constructivist approach on academic achievement of biology at higher secondary level. In this study Quasi-experimental pre-test and post-test design was used by the researcher. 40

students of the senior secondary class of Demonstration Multipurpose School of Regional Institute of Education, Bhubaneswar were assigned as samples of this study. For the treatment, the 5E constructivist model has been used by the researcher in the experimental group. Close-ended questionnaires were administered before and after the treatment. Analysis of the covariance test was performed to test the hypothesis. The findings revealed that students taught through the constructivist approach had higher scores on the concepts of digestion and absorption in the post-test compared to those exposed to the conventional (traditional) method of teaching.

Chowdhury (2016) investigated the topic of "A study on the effect of the constructivist approach on the achievement in mathematics of IX Standard Students". This study explored under following objectives i.e. 1. To study the effectiveness of the Constructivist Approach on the student's achievement in Mathematics in IX standard. 2. To study the effectiveness of the Constructivist Approach on the student's achievement in Mathematics with respect to their gender. 3. To examine the different dimensions of achievement in mathematics of Secondary School Children. Purposive sampling was used for selecting the school and random sampling was used for dividing the experimental and control group. In this study, a non-equivalent pre-test post-test quasi-experimental design has been used by the researcher. 5E's learning (Engage-Explore-Explain- Elaborate-Evaluate) strategy has been applied to the experimental group and the Traditional method of teaching is used for teaching the control group. 60 students of class 9th standard of Asam board were selected as samples of this study. The Mathematics Achievement Test (MAT) was used to estimate the students' achievement in both groups. For the analysis of result percentage, mean, standard deviation, and t-test has been used. The experimental data revealed the following results. Firstly, the Constructivist learning approach significantly improves student's achievement in mathematics as compared to using a traditional teaching method. Secondly, the Constructivist learning approach was equally effective for boys and girls in improving their achievements in mathematics. Thirdly, students taught in the constructivist learning environment have significantly enhanced their understanding and application abilities as compared to other abilities like knowledge and skill.

Khader (2016) intended to determine whether integrated learning may raise kids' performance in science in the third grade when compared to the traditional technique.

108 male and female students were split into two groups for the study: the experimental group and the control group. While the control group studied the identical units using the usual technique, the experimental group used blended learning to study the third-grade material changes and the components and functions of plants. To gauge the progress, an achievement test was created for the scientific course's aforementioned units. The study sample was given it, and the relevant statistical analyses were carried out. The experimental group's teaching approach was shown to have produced statistically significant variations in post-achievement, according to the data. It was found that there was a statistically significant gender difference in the post-achievement, favoring males and that there was no statistically significant gender interaction in the post-achievement.

Kumar (2016) investigated whether the constructivist approach is feasible and effective for biology teaching or not under the topic 'Teaching biology at senior secondary level through constructivist approach'. This study was based on the pre-test and post-test equivalent quasi-experimental design. The objectives of the study were 1. To study the effectiveness of CLS in terms of students' achievement in biology. 2. To study the effectiveness of CLS in terms of students' reaction towards CLS for teaching biology. The sampling procedure was done by the convenient sampling method. The sample of this study was 44 students of the CBSE-affiliated school in Surat district. For data collection, the researcher used an achievement test and student response scale on the constructivist approach. For the analysis of data, u-test has been used by the researcher. The result manifested that the constructive learning strategies (CLS) were found to be significantly effective in terms of enhancing student's achievement in biology in comparison to the traditional approach. The constructive learning strategies (CLS) were also found to be effective in terms of the reaction of students towards it.

Ogonnaya et al. (2016) looked into how concept mapping affected basic science students' performance. The Nigerian state of Ebonyi hosted the study. A quasi-experimental design was used in the investigation. The study used a pretest-posttest non-equivalent control group research design. Using simple random selection, a sample of 122 pupils was chosen from the population at two secondary schools. The purpose of one school was treatment, and the other was control. Basic science was taught to the treatment group using a concept mapping approach, while the other

group received instruction using a traditional method. The data were analyzed using the mean, standard deviation, and the analysis of covariance. The findings indicated that concept mapping, as opposed to the traditional method, improves students' achievement in basic science. It was discovered to raise male and female students' performance in the topic. There is no relationship between gender and instructional strategies and students' proficiency in fundamental science.

Parikh (2016) investigated a study titled "Effectiveness of Teaching through Mind Mapping Technique." The purpose of the current study, which used mind mapping techniques, is to evaluate how successful teaching is. In order to assess the efficacy of mind-mapping instruction, the researcher employed Tony Buchanan's mind-mapping methodology. This is the fundamental reason for the research's design of the class 8th Social Science Subject mind mapping case study, which examined the usefulness of the mind mapping approach in connection to the students' academic achievements. In this study, academic achievement was considered a dependent variable, gender was considered a converter variable, and the teaching approach was considered an independent variable. This study was experimental in nature because two groups were formed to test the efficacy of the mind-mapping method. While the control group received instruction using a conventional approach, the experimental group was instructed using a mind-mapping methodology. A sample of 120 pupils from Prerna School, a Gujarati-medium high-elementary school located in Sector-6 of Gandhinagar, was chosen by the researcher. Case criteria were developed in order to assess the mind-mapping technique's efficacy. After calculating the T-ratio using the test case average, standard deviation, and standard error of the average score, as well as the aspect of the mind mapping technique as revealed by the completed questionnaires, conclusions were drawn. It was discovered that the mind mapping technique was more successful than the traditional method.

Rachel et. al. (2016) investigated the effect of creating constructivist and transmissive learning environments on the achievements of science students of different ability levels under the title Learning Environments as Basis for Cognitive Achievements of Students in Basic Science Classrooms in Nigeria. The sample of this study was 243 students, 122 students in constructivist classrooms and 121 students in transmissive classrooms. In this research, there were two questions tested such as 1. What difference exists between achievement tests of students taught basic science in a

constructivist learning environment and those taught in a transmissive learning environment? 2. Is there any difference in basic science achievement test scores of high-ability students and low-ability students exposed to a constructivist learning environment and the transmissive learning environment? Three instruments (teaching guides, scholastic ability test, and Basic science achievement test), were used to obtain data from the sample. t-test has been used by the researcher for analysis of the data. Results indicated that students in the constructivist environment achieved more. And that the high-ability students, irrespective of their learning environment, achieved more than the low-ability students, which indicates that learning environments do not have an impact on learning ability. However, the high and low constructivist groups achieved more than the high and low transmissive groups, respectively.

Sandhu (2016) conducted a study to know the effect of constructivism and awareness training model on the academic achievement of elementary school students in science. This study focused on the objective "to study whether the group taught through constructivist approach and group taught through traditional method of teaching differs in mean gain scores on academic achievement, and to study whether the group taught through awareness training model and group taught through constructivist approach differ in their mean gain scores on academic achievement." For this study, the quasi-experimental pre-test post-test control group design under the quantitative approach has been adopted by the researcher. The sample was drawn by multistage purposive sampling i.e. first stage, the school was selected, and in the second stage, the student was selected 122 students from Government Senior Secondary School, Bahadurgarh, Patiala, and 124 students from Government Senior Secondary School, Tripuri, Patiala. The experimental group, 'A', having students from both schools, was given treatment according to the lesson plans prepared by using the Awareness Training Model. The experimental group 'B' had students from both schools were given treatment according to the lesson plans prepared by using constructivism. The control group 'C', having students from both schools was given treatment according to the lesson plans prepared by the traditional method of teaching. The achievement of the students recorded on the achievement test. ANOVA and t-tests were used for the data analysis. The findings revealed that constructivist learning cannot be developed through the traditional chalk-and-talk method of teaching and the Constructivist Approach not only assisted the students in constructing basic concepts in science but

also helped to understand the abstract concepts of science in later stages of education. Concepts constructed by the students through constructivism cannot be forgotten and increase the permanence of learning.

Shukla (2016) has tried to investigate the effect of the constructivist approach under the topic Effectiveness of the Constructivist Approach in Teaching Science at the Upper Primary Stage. The sample of this study was 116 students (27 control and experimental in private and 31 control and experimental in govt. school) of U.P. board in Lucknow. For the selection of students, the random selection technique has been used. This study investigated under objective 1. To compare the achievement of students exposed to constructivist approach-based teaching-learning with that of students exposed to traditional mode teaching. Following tools have been used for data collection: Constructivist Approach based teaching learning strategy, Science Achievement Test, Reaction Scale for Students and Perception Scale for Teachers. For the analysis of data t-tests, chi-square, and percentage analysis were used by the researcher. The result manifested that the constructivist approach played a significant role in the achievement of different science subjects (physics, chemistry, and biology).

Adak (2017) investigated the effectiveness of the constructivist approach on academic achievement in science at the secondary level. In this study quasi-experimental pre-test, post-test, experimental, and control group research design has been used. This study was conducted to achieve two objectives i.e. 1. To study the effect of the constructivist approach over the traditional method on students' achievement in physical science. 2. To compare the effect of the constructivist approach over the traditional method on students' achievement in physical science with respect to their intelligence. The sample of this study comprises 58 students grouped as experimental group (29) and control group (29) based on matching by intelligence test. The investigators conducted this experiment over three weeks by using both traditional and constructivist 7E models. The self-developed achievement test was used as a tool. For the analysis of data statistical techniques Mean, SD, SEM, t-test, and ANOVA have been used by the researcher. The result of this study manifested that the students exposed to the constructivist 7E model significantly achieved better than the traditional method. In addition, students exposed to the 7E model performed significantly higher than those exposed to the traditional teaching method with respect to their gained scores at every intelligence level.

Alghamdi (2017) studied the “Impact of Jigsaw on the Achievement and Attitudes of Saudi Arabian Male High School Science Students”. The study aims to investigate the impact of cooperative learning instruction, specifically by using the Jigsaw instructional strategy on science achievement and attitudes toward science among 11th-grade students. Based on previous research literature, it was hypothesized that significant differences existed in gains between the general science achievement of the experimental group and the control group. The quasi-experimental design was chosen for this study. The study sample consisted of 50 students of the 11th-grade class who were equally distributed among the experimental group and control group, matched based on their annual examination at general science scores. The students' achievement was measured through the implementation of the 30-item achievement test used as a pretest, as well as a post-test and deferred (follow-up) test. The experiment group was taught through cooperative learning while the control group was taught through the instructions of "traditional teaching". The material was used such as lesson plans, worksheets, and quizzes, designed to implement Jigsaw as a cooperative learning methodology. For the attitude scale towards science, a published 30-item Likert scale called Test of Science Related Attitudes (TOSRA) has been used to determine the students' attitudes. The data were analyzed through repeated measure analysis and multivariate analysis of variance with a .05 selected level of significance. The results of this study showed that using Jigsaw as a cooperative learning strategy has improved the students' achievement for the benefit of the experimental group. However, there was no significant change in the student's attitudes towards science for both groups, where the scores of all the attitude subscales were at or near the neutral level.

Fernando and Marikar (2017) have examined General Sir John Kotelawala Defense University’s cadet and civilian students’ response to constructivist learning theory and participatory teaching methods, especially concepts and knowledge on the learning platform in the defense University under the topic Constructivist Teaching/Learning Theory and Participatory Teaching Methods. The target population of this study represents 41 students, 11 students were defense cadets, and 31 students were general civilians. All students were given a questionnaire related to constructivist learning theory and participatory teaching methods. For the analysis of data simple percentage has been used by the researcher. The claims of constructivist teaching/learning theory

that this paper has singled out are the following: 1) learning is an active experience; 2) the ideas students hold about the subject and topic being taught will form a part of their learning experience; and 3) learning is socially and culturally rooted.

McWright (2017) conducted a study on comparative study teaching chemistry using the 5E learning cycle and traditional teaching with a large English language population in a middle school setting. The purpose of this research was to determine if students' chemistry knowledge and interest can be increased by using the 5E learning cycle in a middle school with a high population of English language learners. The participants were eighth-grade middle school students in a large metropolitan area. The purposive sampling technique was used to select students. Students participated in a month-long chemistry unit. The study was a quantitative, quasi-experimental design with a control group using a traditional lecture-style teaching strategy and an experimental group using the 5E learning cycle. Students completed pre- and post-student attitude in science surveys, a pretest/post-test for each mini-unit taught, and completed daily exit tickets using the Expert Science Teaching Educational Evaluation Model (ESTEEM) instrument to measure daily student outcomes in the main idea, student inquiry, and relevancy. Mann-Whitney U test was used to analyze the data. Analysis of the data showed that there was no statistical difference between the two groups overall, and all students experienced a gain in content knowledge overall. All students demonstrated a statistically significant difference in their interest in science class, activities in science class, and outside of school. Data also showed that scores in writing the main idea and writing inquiry questions about the content increased over time.

Pangat (2017) examined the effect of the constructivist approach pedagogy on the academic achievement of secondary school students in mathematics under an objective i.e. To examine the effectiveness of the constructivist approach in the academic achievement of secondary school students in mathematics. A pre-test, post-test Equivalent Group Design with randomized experimental and control groups was used. The sample of the present study consisted of 50 mathematics students. The selection of the school was done through the purposive sampling method. A simple random sampling method was used to divide the students into two groups. A Self-made achievement test in mathematics was administered to all the students. The test was conducted in two stages a pre-test and a post-test. The data was analyzed by using

the statistical techniques mean, standard deviation, and t-test. Two results come to light 1. The performance of mathematics students taught with the constructivist approach was better than that of the group taught by the conventional approach. 2. Most of the students showed remarkable improvement in their abilities of understanding and reflection.

Sandhu (2017) investigated the effect of the Constructivist approach on academic achievement in relation to the Intelligence of Elementary School Students in Biology was investigated. Pre-test Post-test control group experimental design was followed. This study investigated under two objectives i.e.- 1. To study the effect of the constructivist teaching approach on the academic achievement of elementary school students in biology. 2. To study the effect of the constructivist teaching approach on biology as compared to the traditional method of teaching in relation to intelligence. The sample of this study was 120 students, picked up for the study comprising two groups of 60 students each viz. control and experimental group. For the analysis of data mean, standard deviation, t-test, and ANCOVA has been used by the researcher. The study shows that the constructivist teaching approach exhibits a significantly higher level of academic achievement and exhibits significant interaction between the Teaching Techniques and Intelligence on Academic Achievement in biology. The results revealed that Constructivism plays a central role in increasing academic achievement and the acquisition of the concepts of biology.

Yaduvanshi and Singh (2018) examined the Effect of cooperative learning (STAD method) on Biology achievement of rural and urban students at the secondary level with the research question any differences exist in school achievement among rural and urban background students with respect to instructional methods (traditional and cooperative learning strategy) used. Objectives of this study were 1. To find out the effect of structured CL strategy (STAD) on students' achievement in biology with respect to the area of residence of the students. The researcher adopted the randomized, pre-test – post-test randomized group experimental design. A total of 63 students from class IX participated in the experiment. For data collection, biological achievement test has been used which was prepared by the researcher. For the analysis of data statistical technique ANCOVA was used in this study. The results revealed that the structured cooperative learning strategy (STAD method) enhanced students' achievement in biology and findings were in Favor of rural students. The study

revealed that the implementation of structured CLS can improve the achievements of rural students and can be used as a tool to fill the gap between the inequality of achievements in rural and urban students in the science classroom.

Kalyanasundaram (2018) conducted a study for the enhancement of science process skills through the cognitive constructivism-based learning strategy in science at the secondary level. The major objectives of the study were to develop a cognitive constructivism-based learning strategy to enhance science process skills acquisition for ninth-standard learners and to find its effectiveness. In this study, the randomized two groups: pre-test and post-test parallel design (true experimental design) was implemented by the researcher. 50 students from class nine were selected as the sample by simple random sampling. 25 students were randomly assigned to the control group, and the other 25 students were randomly assigned to the experimental group. Four tools were used for data collection i.e. Pretest for science process skills (SPST-I), Post-test for science process skills (SPST-II), Retention test for science process skills, and Interview Schedule. Mean and t-tests were used for analyzing the data. The findings revealed that the cognitive constructivism-based learning strategy was more effective than the traditional method. Moreover, the enhancement of the processing ability of science process skills enables learners to retain them for a prolonged time to make learning permanent.

Sheela (2018) looked into how science achievement, critical thinking, and social maturity of secondary school students were affected by social constructivist teaching strategies. This study used a parallel group design with pre-and post-tests. The study employed random sampling technique using a sample of ninth-standard students from Mysore city schools. The data was gathered using the Critical Thinking test, Social Maturity scores, and Science Achievement Test. The data were analyzed using the t-test, two-way ANOVA, and Pearson Product Moment Correlation. The study's conclusions showed that teaching science using social constructivist methods was more successful in raising secondary school students' scientific achievement, critical thinking skills, and social maturity. The findings also showed that secondary school students' achievement in science, critical thinking, and social maturity were positively and significantly correlated.

Bawaneh (2019) compared how well Jordanian tenth graders retained and immediately grasped ideas related to electric energy between the use of mind maps and traditional teaching methods. Participants were chosen at random from the Bani Kenanah region, which is located north of Jordan (N = 111 students; M = 52, F = 59). The Mind Maps Teaching Method (n = 54) was used in one group, and the Conventional Teaching Method (n = 57) was applied to another. Open-ended questions and a multiple-choice physics concept test were created and utilized. Data were analyzed by the mean, SD, and F-test. The findings demonstrated that when it came to the quick acquisition and retention of concepts related to electric energy, the Mind Maps teaching method outperformed the Conventional Teaching method. Regarding initial achievement, there was a notable difference in gender among the pupils.

Gezim & Xhomara (2020) examined the connections between academic success in science education, problem-based learning, and student-centered teaching methods. For this study, a quantitative quasi-experimental research design was chosen. The structured questionnaire was used to gather study data. The study's sample comprised two groups: a control group (N = 204) and an experimental group (N = 215), chosen by cluster random sampling. The findings demonstrated a noteworthy distinction between the experimental and control groups of students' academic success scores, problem-based learning, and student-centered teaching methodology. Although there were notable disparities between the experimental and control groups, it was discovered that there was a weak positive link between academic achievement and a student-centered teaching method. Although there were notable variations between the experimental and control groups, the study found a medium-positive link between academic achievement and problem-based learning. The findings showed that problem-based learning and student-centered instruction accounted for a comparatively large amount of the overall variance in academic success levels.

Chandi (2020) conducted a study titled Constructivism in Teaching and Learning in Indian Context: Content Analysis & Evaluation. In this study Content analysis approach is used to evaluate teaching and learning in the Indian context in the light of constructivism. The primary aim of this study is to explore the progress and trends of constructivism. The objectives of this study were 1. To know the concept of Constructivism. 2. To be aware of the importance of constructivism in various

branches of knowledge. 3. To illustrate the whole scenario of the constructivist approach in Teaching & Learning. 4. To understand the trends of constructivism. Documentary analysis, as well as the content analysis method of the qualitative approach, has been used to analyze content related to constructivism. The investigator used forty published articles from different journals for in-depth study. The reviewed studies conclude that the constructivist approach is also positively effective in teaching-learning situations in the various fields of education. Students are also intrinsically motivated and doing much better performance through the teaching of the constructivist approach other than any approach. Students also gained problem-solving, flexibility in thinking, reflective thinking, and reasoning skills, and learned to make connections and associations by relating the subject matter to their own life experiences.

Ginga and Zakariya (2020) conducted a study to assess the impact of a social constructivist instructional strategy on performance in algebra with a focus on secondary school students. The major objective of the study was to investigate the impact of a social constructivist instructional strategy on students' performance in algebra. In the present study, the quasi-experimental post-test control group design was used. For the intervention, 154 secondary school students were randomly selected across four intact classes. 30-item multiple-choice test with four option categories Algebra performance test (APT) was used for the data collection and the t-test was used by the researcher. The findings indicate the effectiveness of the social constructivist instructional strategy in improving performance in algebra better than the conventional teaching method. The effect of the social constructivist instructional strategy on students' performance in algebra is gender sensitive.

Ugwuozor (2020) conducted a study titled "Constructivism as Pedagogical Framework and Poetry Learning Outcomes among Nigerian Students: An Experimental Study." The major objective of the study was to examine the impact of constructivism on poetry learning among junior high school students in southeast Nigeria. In this study, the Quasi-experimental pretest-post-test experimental design has been adopted by the researcher. The population of students in Junior Secondary School 2 (JSS 2) in Isi-Uzo Local Government Area (LGA) in Enugu State was 12,345, with an almost equal distribution of males and females, 6340 boys and 6005 girls. Through purposive sampling school with about 96 students in JSS 2 class was

selected. From this cohort, a sample size of about 77 students was determined and randomly selected. Self-made essay-type questionnaire Poetry Achievement Test (PAT) was used by the researcher. Repeated-measures ANOVA was employed to test the significance of improvement or change in individual participants and across control and treatment groups. Univariate ANOVA was used to test gender differences in test scores. Results show a significant effect of the constructivist method on achievement among students in the treatment group compared to the control group. The results also show that the effect of the constructivist method on students' achievement was not determined by gender.

Joshi (2021) investigated a study titled "Thesis Effect of Connectivism based strategies on Critical Thinking Ability Problem-solving Ability and Achievement in Science among Secondary School Students". The relevant objective was. To assess the levels of Achievement in the science of secondary school students. The Post-test-only control group design was adopted to find out the effect of Connectivism Based Strategies on Achievement in science among secondary school students. Multistage sampling technique was adopted - In the first stage the schools were selected and in the second stage the classes were allotted to experimental and control groups. The purposive sampling technique was adopted to select the secondary schools from Mysore city. There were two sections of ninth standard in both the selected schools, so by using the lottery method one section was randomly assigned to the experimental group and one section was randomly assigned to the control group in both schools. Critical thinking ability test, Problem-solving ability test, and Achievement test in science were used for the data collection from the sample. Percent analysis, t-test, and ANOVA were used for analyzing the data. The results have depicted that the Experimental group was found to benefit more than the control group concerning the enhancement of Achievement in science. Connectivism Based Strategies are more effective in the development of Achievement in science among secondary school students.

Habtamu et al. (2022) investigated the Effect of the Cooperative Problem-Solving Method on Students' Motivation Towards Learning Algebra. The major objective was to examine the effect of the cooperative problem-solving method on grade nine secondary school students' motivation towards learning algebra. To achieve the objective pretest-posttest non-equivalent group design was used under the quasi-

experimental design. From these secondary schools, three grade nine intact classes with a total number of 142 students were selected using the simple random sampling technique for forming treatment and comparison groups. 47 students (18 males, and 29 females) in the control group, 47 students (27 males, and 20 females) in treatment group one, and 48 students (19 males, and 29 females) in the treatment group, two, were found. On five rating scale mathematics motivation questionnaire (MMQ) data was recorded. Mean, standard deviation, paired sample t-test, analysis of variance (ANOVA), and analysis of covariate (ANCOVA) were used to analyze the data. The result revealed that The result revealed that there was a statistically significant mean difference between groups on intrinsic goal orientation, extrinsic goal orientation, task value, control of beliefs for learning, self-efficacy, and total motivation of students to learn algebra. Besides, except test anxiety motivation component, students' motivation and its components to learn algebra were affected by cooperative problem-solving and problem-solving methods.

Dahal (2023) conducted a study titled Concept Mapping: Unleashing the Power of Visual Learning in Science Education. The major objective of the study was to determine the effectiveness of concept mapping as visual representations in increasing understanding of concepts and knowledge retention among secondary school students studying science. Quasi-experimental pre-test post-test control group design has been used in this study. 45 students for the experimental group and 50 students for the control group were chosen at random from two public secondary schools in Kathmandu and the Lalitpur district. The Achievement of students assessed by Two parallel types of achievement test items containing 40 science-related items concentrating on the areas of Heat and Light were produced. Data were analyzed by using standard deviation, and independent sample t-test. The results revealed that concept mapping improves students' conceptual understanding and knowledge retention as concept mapping considerably increased students' post-test scores when compared with conventional methods of instruction that were without concept mapping.

Mbarute et al. (2023) investigated the Effects of cooperative learning strategy on students' academic achievement in physics. The relevant objective was to determine whether the cooperative learning strategy affects the academic achievement of students in Physics. The quasi-experimental design was used in the research. The

sample size consisted of 200 students comprising 94 in the control group and 106 in the experimental group. For the data collection physics achievement test was used. Descriptive statistics, Pearson correlation, independent sample t-test were used for analyzing the data. Results revealed that Students taught Physics with the cooperative teaching method have higher academic achievement than those taught with the lecture method of teaching.

Munir (2023) conducted an experimental study to investigate how mind-mapping activities affect students' recall of information, academic performance, and learning. Elementary school science was the focus of the investigation. The purpose of the study was to determine how mind-mapping exercises affected primary school science students' learning at various levels of Bloom's taxonomy's cognitive domain (knowledge, understanding, application, and analyses). Using a random sampling technique, eight-grade students from a public school in a Punjabi district were selected as samples. The kids were taught using the mind-mapping technique. It was decided to use the Pre-test-Post-test Equivalent-Groups Design. The eighth graders were taught mind-mapping exercises over the course of two months of lesson planning. Two groups were created: the control group and the experimental group. The results of the two groups were compared using a T-test. The study's conclusions showed that pupils in the experimental group made statistically significant and greater gains than those in the control group. The findings from mind mapping exercises demonstrated the beneficial effects of the technique on students' learning.

Pathak and Tamra (2023-24) investigated a study titled “Effectiveness of Collaborative Learning in Science at Secondary Level”. For this purpose, the researcher has chosen 82 class ninth students with the help of convenient sampling. In this study, the “pre-test post-test control design” of quasi-experimental research was applied by the researcher. The major objective of the research was to examine the effect of collaborative learning in comparison to the lecture method. For data collection, a self-prepared achievement test was used by the researcher. Mann-Whitney U test was used to analyze the data, and the results depicted that both groups were equally performing after the intervention.

Ebokaiwe et al. (2024) investigated how long Delta State physics students stayed in class using lecture techniques, team teaching, and 5e-guided inquiry. Two research

questions and two hypotheses were posed and assessed at the 0.05 level of significance in order to direct the investigation. The quasi-experimental non-randomized planned variation group design was employed in the study for the pre-, post-, and delayed post-tests. With 476 secondary schools and 31,711 SS2 students, the population was made up of all Delta State mixed public secondary school (SS2) Physics students. 326 pupils from a sample of six (6) secondary schools were included in the study. The study's six (6) participating schools were chosen through the use of a stratified random sampling method. The instrument employed to gather data was the Physics Achievement Test (PAT). All study issues were addressed using the mean and standard deviation, and the acquired data were examined using both analysis of variance (ANOVA) and analysis of covariance (ANCOVA). The findings showed that students who were taught using the team-teaching approach outperformed those who were taught using the lecture and 5E-guided inquiry methods. Additionally, the outcome demonstrated that the relationship between sex and method had no discernible impact on physics students' retention.

Mohapatra and Kumari (n.d.) investigated the impact of a constructivist approach on higher secondary biology students' academic achievement. The study involved forty senior secondary school students from the Demonstration Multipurpose School class XI of the Regional Institute of Education, Bhubaneswar. In this study, the quasi-experimental design was used. A constructivist technique was randomly chosen to train one part (the experimental group), while a conventional strategy was used to instruct the other group (the control group). Eleven guys and ten girls made up the experimental group of twenty-one pupils. The control group, on the other hand, was made up of nine boys and ten girls. The researcher created two kinds of closed-ended questions. There were two types of questionnaires: one with 35 multiple-choice questions and another with 20 statement-based questions. The surveys were given out both before and after the procedure. Data were analyzed by t-test and ANCOVA. The outcomes that supported constructivist learning's beneficial effects. The results showed that teaching biology with a constructivist approach is a good substitute for more conventional teaching techniques.

2.1.1 OBSERVATIONS

The investigator has reviewed total 60 studies on the theme strategy developed on constructivism. Out of 60 studies, 42 studies were conducted in abroad and 18 studies were conducted in India.

Under the umbrella of constructivist approach studies conducted on the constructivism (Gatlin, 1998; Huseyin et al., 2003; Becker and Maunsaiyat, 2004; Donaldson, 2004; Kroesbergen, 2004; Puacharearn and Fisher, 2004; Liang and Gabel, 2005; Vaca, 2010; Secken and Alsan, 2011; Bhutto and Chhapra, 2013; Bhaskar, 2014; Ayaz and Sekerci, 2015; Aydisheh and Gharib, 2015; Mohapatra and Kumari, 2015; Chawdhury, 2016; Kumar, 2016; Rachel et al., 2016; Sandhu, 2016; Shukla, 2016; Adak, 2017 (7Es model), Fernando and Marikar, 2017; McWright, 2017; Pangat, 2017; Sandhu, 2017; Kalyanasundaram, 2018; Sheela, 2018; Chandi, 2020; Ginga and Zakariya 2020; Ugwuozor, 2020; Joshi, 2021), mind map (Williams, 1999; Cunningham, 2006; Beena, 2008; Nong et al., 2009; Abi-El-Mona and Adb-El-Khalick, 2010; Seyihoglu and Kartal, 2010; Dhindsa et al., 2011; James, 2011; Balim, 2013; Blessing and Olufunke, 2015; Mitra, 2015; Parikh, 2016; Bawaneh, 2019; Munir, 2023), concept map (Ogonnaya et al. 2016; Dahal, 2023) Inquiry based pedagogy (Foster, 2011; Nail, 2011), problem based learning (Loyens et al., 2006; Dobbs, 2008; Gezim and Xhamara, 2020; Habtamu et al., 2022;), brainstorming (Rizi et al., 2013), integrated learning (Khader, 2016;), guided inquiry (Ebokaiwe et al., 2023), cooperative learning (Alghamdi, 2017; Yaduvanshi and Singh, 2018; Mbarute et al., 2023), collaborative learning (Pathak and Tamra, 2024)

The research designs fallowed in the reviewed studies were Quasi-experimental design (Gatlin, 1998; Williams, 1999; Huseyin et al., 2003; Becker and Maunsaiyat, 2004; Donaldson, 2004; Kroesbergen, 2004; Puacharearn and Fisher, 2004; Liang and Gabel, 2005; Cunningham, 2006; Loyens et al., 2006; Dobbs, 2008; Beena, 2008; Vaca, 2010; Abi-El-Mona and Adb-El-Khalick, 2010; Seyihoglu and Kartal, 2010; Dhindsa et al., 2011; Foster, 2011; James, 2011; Nail, 2011; Balim, 2013; Bhutto and Chhapra, 2013; Ayaz and Sekerci, 2015; Mohapatra and Kumari, 2015; Chawdhury, 2016; Kumar, 2016; Rachel et al., 2016; Sandhu, 2016; Shukla, 2016; Adak, 2017 (7Es model), Alghamdi, 2017; Fernando and Marikar, 2017; McWright, 2017; Pangat, 2017; Sandhu, 2017; Sheela, 2018; Yaduvanshi and Singh, 2018; Chandi, 2020; Ginga and Zakariya 2020; Ugwuozor, 2020; Joshi, 2021; Mitra, 2015; Dahal, 2023; Habtamu et al., 2022; Ebokaiwe et al., 2023; Mbarute et al., 2023 Pathak and Tamra,

2024), true experimental design (Huseyin et al., 2003; Nong et al., 2009; Secken and Alsan, 2011; Rizi et al., 2013; Bhaskar, 2014; Aydisheh and Gharib, 2015; Blessing and Olufunke, 2015; Khader, 2016; Ogonnaya et al. 2016; Parikh, 2016; Kalyanasundaram, 2018; Bawaneh, 2019; Munir, 2023), Descriptive design (Bhutto and Chhapra, 2013).

The sampling methods fallowed in the reviewed studies were purposive sampling (Gatlin, 1998; Williams, 1999; Huseyin et al., 2003; Becker and Maunsaiyat, 2004; Donaldson, 2004; Kroesbergen, 2004; Puacharearn and Fisher, 2004; Liang and Gabel, 2005; Cunningham, 2006; Loyens et al., 2006; Beena, 2008; Dobbs, 2008; Abi-El-Mona and Adb-El-Khalick, 2010; Seyihoglu and Kartal, 2010; Vaca, 2010; Dhindsa et al., 2011; Foster, 2011; James, 2011; Nail, 2011; Bhutto and Chhapra, 2013; Balim, 2013; Ayaz and Sekerci, 2015; Mitra, 2015; Mohapatra and Kumari, 2015; Chawdhury, 2016; Kumar, 2016; Rachel et al., 2016; Sandhu, 2016; Shukla, 2016; Adak, 2017 (7Es model), Alghamdi, 2017; Fernando and Marikar, 2017; McWright, 2017; Pangat, 2017; Sandhu, 2017; Sheela, 2018; Yaduvanshi and Singh, 2018; Chandi, 2020; Ginga and Zakariya 2020; Ugwuozor, 2020; Joshi, 2021; Habtamu et al., 2022; Dahal, 2023; Ebokaiwe et al., 2023; Mbarute et al., 2023), random sampling (Huseyin et al., 2003; Nong et al., 2009; Secken and Alsan, 2011; Bhaskar, 2014; Aydisheh and Gharib, 2015; Blessing and Olufunke, 2015; Khader, 2016; Ogonnaya et al. 2016; Parikh, 2016; Kalyanasundaram, 2018; Bawaneh, 2019; Munir, 2023), cluster sampling (Rizi et al., 2013; Gezim and Xhamara, 2020), convenient sampling (Kumar, 2016; Pathak and Tamra, 2024).

Tools used were an achievement test (Gatlin, 1998; Williams, 1999; Huseyin et al., 2003; Becker and Maunsaiyat, 2004; Donaldson, 2004; Kroesbergen, 2004; Puacharearn and Fisher, 2004; Liang and Gabel, 2005; Cunningham, 2006; Loyens et al., 2006; Beena, 2008; Dobbs, 2008; Nong et al., 2009; Abi-El-Mona and Adb-El-Khalick, 2010; Seyihoglu and Kartal, 2010; Dhindsa et al., 2011; Vaca, 2010; Foster, 2011; James, 2011; Nail, 2011; Secken and Alsan, 2011; Balim, 2013; Bhutto and Chhapra, 2013; Rizi et al., 2013; Bhaskar, 2014; Ayaz and Sekerci, 2015; Aydisheh and Gharib, 2015; Blessing and Olufunke, 2015; Mitra, 2015; Mohapatra and Kumari, 2015; Chawdhury, 2016; Khader, 2016; Kumar, 2016; Ogonnaya et al. 2016; Parikh, 2016; Rachel et al., 2016; Sandhu, 2016; Shukla, 2016; Adak, 2017 (7Es model), Alghamdi, 2017; Fernando and Marikar, 2017; McWright, 2017; Pangat, 2017; Sandhu, 2017; Kalyanasundaram, 2018; Sheela, 2018; Yaduvanshi and Singh, 2018;

Bawaneh, 2019; Chandi, 2020; Gezim and Xhamara, 2020; Ginga and Zakariya 2020; Ugwuozor, 2020; Joshi, 2021; Dahal, 2023; Habtamu et al., 2022; Ebokaiwe et al., 2023; Mbarute et al., 2023; Munir, 2023; Pathak and Tamra, 2024) Likert scale on motivation (Habtamu et al., 2022), rubric (Gatlin, 1998).

The statistical technique used to analyse the data were Mann-Whitney U Test (Beena, 2008; Vaca, 2010; Balim, 2013; Kumar, 2016; McWright, 2017; Pathak and Tamra, 2024), Wilcoxon (Balim, 2013), Cohen's d (Becker and Maunsaiyat, 2004; Ayaz and Sekerci, 2015; Chandi, 2020), t-test (Gatlin, 1998; Williams, 1999; Huseyin et al., 2003; Becker and Maunsaiyat, 2004; Donaldson, 2004; Kroesbergen, 2004; Puacharearn and Fisher, 2004; Liang and Gabel, 2005; Cunningham, 2006; Loyens et al., 2006; Dobbs, 2008; Nong et al., 2009; El-Mona and Adb-El-Khalick, 2010; Seyihoglu and Kartal, 2010; Dhindsa et al., 2011; Foster, 2011; James, 2011; Nail, 2011; Secken and Alsan, 2011; Bhutto and Chhapra, 2013; Bhaskar, 2014; Ayaz and Sekerci, Aydisheh and Gharib, 2015; Blessing and Olufunke, 2015; 2015; Mitra, 2015; Mohapatra and Kumari, 2015; Chawdhury, 2016; Khader, 2016; Ogonnaya et al. 2016; Parikh, 2016; Rachel et al., 2016; Sandhu, 2016; Shukla, 2016; Adak, 2017 (7Es model), Alghamdi, 2017; Fernando and Marikar, 2017; Pangat, 2017; Sandhu, 2017; Kalyanasundaram, 2018; Sheela, 2018; Yaduvanshi and Singh, 2018; Bawaneh, 2019; Chandi, 2020; Ginga and Zakariya 2020; Ugwuozor, 2020; Joshi, 2021; Habtamu et al., 2022; Abi-Dahal, 2023; Ebokaiwe et al., 2023; Mbarute et al., 2023; Munir, 2023), cluster sampling (Rizi et al., 2013; Gezim and Xhamara, 2020), ANOVA (Gatlin, 1998; Williams, 1999; Donaldson, 2004; Puacharearn, and Fisher, 2004; Liang and Gabel, 2005; Nong et al., 2009; Abi-El-Mona and Adb-El-Khalick, 2010;; Foster, 2011; James, 2011; Bhutto and Chhapra, 2013; Sandhu, 2016; Sheela, 2018), Chi-square (Shukla, 2016), MANOVA (Alghamdi, 2017), ANCOVA (Huseyin et al., 2003; Becker and Maunsaiyat, 2004; Liang and Gabel, 2005; Cunninghum, 2006; Mohapatra and Kumari, 2015; Ogonnaya et al., 2016; Sandhu, 2017; Yaduvanshi and Singh, 2018) content analysis (Seyihoglu and Kartal, 2010), Structural equation modelling (Loyens et al., 2006), regression analysis (Bhutto and Chhapra, 2013).

Findings revealed that lecture was effective (Getlin, 1998), lecture and mind map produce same result (William, 1999), lecture and collaborative learning given same result (Pathak and Tamra, 2024), constructivist approach was an effective means for teaching learning science (Huseyin et al., 2003; Becker and Maunsaiyat, 2004;

Donaldson, 2004; Puacharearn and Fisher, 2004; Liang and Gabel, 2005; Cunningham, 2006; Loyens et al., 2006; Beena, 2008; Dobbs, 2008; Nong et al., 2009; Abi-El-Mona and Adb-El-Khalick, 2010; Seyihoglu and Kartal, 2010; Vaca, 2010; Dhindsa et al., 2011; Foster, 2011; James, 2011; Nail, 2011; Secken and Alsan, 2011; Balim, 2013; Bhutto and Chhapra, 2013; Rizi et al., 2013; Bhaskar, 2014; Ayaz and Sekerci, 2015; Aydisheh and Gharib, 2015; Blessing and Olufunke, 2015; Mitra, 2015; Mohapatra and Kumari, 2015; Chawdhury, 2016; Kumar, 2016; Khader, 2016; Ogonnaya et al. 2016; Parikh, 2016; Rachel et al., 2016; Sandhu, 2016; Shukla, 2016; Adak, 2017 (7Es model), Alghamdi, 2017; Fernando and Marikar, 2017; McWright, 2017; Pangat, 2017; Sandhu, 2017; Kalyanasundaram, 2018; Sheela, 2018; Yaduvanshi and Singh, 2018; Bawaneh, 2019; Chandi, 2020; Gezim and Xhamara, 2020; Ginga and Zakariya 2020; Ugwuozor, 2020; Joshi, 2021; Habtamu et al., 2022; Dahal, 2023; Ebokaiwe et al., 2023; Mbarute et al., 2023; Munir, 2023) constructivist approach was an effective means for teaching learning math (Kroesbergen et al., 2004).

2.2 REVIEWS ON COGNITIVE LOAD

Amadieu et. al. (2009) investigated how learning from non-linear materials on "the infection process of a retrograde virus (HIV)" affected disorientation, cognitive load, and prior knowledge (high vs. low; HPK and LPK) and concept-map structure (hierarchical vs. network; HS and NS). In this study, the 2x2 factorial design was used to conduct experimentation. 24 participants were selected through convenient sampling. There were twenty-four adult study participants. Eye movement and navigation data were thoroughly analyzed, and overall subjective ratings of disorientation and cognitive load were employed. Data were analyzed by the Mann-Whitney U test. The findings demonstrated that LPK learners acquired greater conceptual information from the HS concept map, got equal amounts of factual knowledge from the NS and HS concept maps, and required less mental work to complete the posttest after using the HS concept map. However, HPK students learned the same amount of conceptual knowledge from both concept-map formats and more factual knowledge from the HS concept map than the NS concept map. Additionally, when learning with the NS concept map as opposed to the HS map, LPK learners reported feeling more disoriented, whereas HPK learners showed no

discernible difference in the impact of the concept map structure. Less mental effort was expended by LPK and HPK learners in processing the HS concept map.

Liang and Lai (2013) analyzed the lack of equipment for color management and inspection instruction as improving learning results and reducing cognitive load. The investigators created 3D courseware for color management and inspection through a research and development process. The sample size of eighty students was given ten-week-duration long experimental instructions into four groups, each consisting of twenty students. The analysis using MANCOVA was carried out. The findings were that the students who received the lecture and instructions incorporated by 3D courseware was found to be at more significant level than the other three learning results. The courseware developed for this study improved learning results while lowering the cognitive load. Findings are helpful for color management and inspection-related training in colleges and industry.

Lee (2013) reviewed (HGRA), the Hierarchy Grey Relational Analysis for data analysis obtained from the EFL (English as a Foreign Language) students' cognitive load in English public speaking. The study was conducted on 31 students who opted for English as a Foreign Language, and the teacher familiarized them with nine criteria of abilities in public speaking training. Based on the findings, to tailor to students' cognitive load for best training results, the teacher should start with easier, more concrete techniques such as motor skills, prepare useful visual aids, and finally proceed to the abstract, logical organization of the main points. Additionally, the teacher can even offer differentiated practices to those whose cognitive load levels in speech skills are different.

Figen (2014) evaluated the students' outcomes produced by digital storytelling and determined the awareness of learning the topic and students' cognitive loads. The study was conducted among 52 primary teachers. The result revealed that digital storytelling helped student recognize their self-improvement. The student's cognitive load is not increased much by the performed application. Digital storytelling is very useful for students to learn by utilizing their visual, audio, and kinesthetic capacity. Students who rarely use computers have a high cognitive load, and most of the low cognitive load students are familiar with computers.

Andrade et al. (2015) conducted a study to explore the effect of multimedia and content difficulty on students' Cognitive load and learning outcomes. The comparison of Intrinsic, Extraneous, and Germane Cognitive load was done. The investigation was performed among 268 college students, by dividing them into three groups Group I – TG, II – ATG, and III-VATG. Before viewing two (2) food science supplement lecture materials, a demographic survey and pre-test were answered by this group of students, and on completing the cognitive instrument a post-test within a noncontrolled setting was conducted. Cognitive load scores were tabulated and compared using a 3 × 3 ANOVA and Tukey post-hoc analysis across multimedia groups. Students in group – I (TG) have higher intrinsic cognitive load scores than group –II (ATG) based on the post –hoc test. Spearman correlation was used to compare the cognitive load and post–test scores. Group –I (TG) students who reported less Intrinsic Cognitive Load and more Germane Cognitive Load had higher post-test scores. Group II (ATG) and Group – III, students who reported less Extraneous Cognitive Load had higher post-test scores.

Akkaraju (2016) focused on the flipped learning students' pass rates than those in non-flipped learning; the study was conducted over four semesters in a Human Anatomy and Physiology course. Participants include 90 students. Compared to general student performance, the flipped learning model effectively approaches the cognitive load (CLT) in learning physiology, which usually has a high cognitive load. By reducing the extraneous cognitive load (ECL) via intentional content, managing intrinsic cognitive load (ICL) via pre-training and retrieval practice, and increasing (GCL) germane cognitive load via the extended class time reserved for problem-solving, the flipped learning model offers a very supportive learning situation with many possibilities for self-regulated learning for learners struggling to master this threshold concept.

Hadie & Yusoff, (2016) assessed the problem-based learning environment by testing its construct validity and internal consistency the research conducted a cross-sectional study. The sample of first-year medical students 125 students participated. The Confirmatory factor analysis was performed to test used for construct validity. The internal consistency of this inventory was determined through reliability analysis. As a result, a total of 93 medical students completed the inventory. The scale's Cronbach's alpha was more than 0.7, showing a high level of internal consistency. All the items

attained a standardized factor loading of more than 0.5, with high contributions to the respective scales. The mean levels of students' intrinsic cognitive load and self-perceived learning were high, and the mean level of students' extraneous cognitive load was low. These findings signaled those students learned well during the class despite challenging instruction because the cognitive load level is an essential outcome for instructional design efficiency.

Turan and Goktas (2016) focused on the flipped classroom method's performance and its effects on students' achievement and cognitive load levels. The major objective of the study was to study the effect of the flipped classroom method of teaching on academic achievement and cognitive load. The flipped classroom method is compared to traditional techniques through quasi-experimental research. Participants are 116 prospective teachers assigned to experimental (N=58, 3 males and 55 females) and control groups (N=58, 10 males and 48 females). The study was conducted over ten weeks. For data analysis t-test and MANOVA has used by the researcher. Results explained that students taught with the flipped classroom model reported higher learning achievements and lower cognitive loads than those taught with the traditional model. The students' instructional efficiency scores in the experimental group were 35 also higher than those of the students in the control group. Hence, the flipped classroom method can be considered a useful approach in higher education settings when designed effectively.

Klepsch et al., (2017) aimed to develop a differentiated measurement of cognitive load such as Intrinsic, Extraneous and Germane Cognitive Load. Analyzed two strategies to measure cognitive load positively: a) Informed rating b) Naïve Rating. a) Informed rating checked for comparability of the two measurement strategies. In naive rating the researcher conducted a simultaneous scenario-based factor analysis. The strategy to assess cognitive load's different aspects seems not feasible and economical for more extensive studies, and standardized training would be essential. The enhanced version of the naïve rating became a useful, reliable, and feasible tool.

Permana et al. (2017) conducted a study on The Extraneous Cognitive Load (ECL) of students in the Pedagogical Content and Knowledge of Solar System Course which was examined by Thirty-one pre-service elementary school teachers served as the samples. Following a lecture, the data was gathered via an interview and a Likert 4-

point scale questionnaire. The Extraneous Cognitive Load (ECL) assessment courses required pre-service elementary school teachers to put in mental effort, according to the study. Using the Vee Diagram framework, the classes involved creating both experimental and non-experimental worksheets as well as analyzing the curriculum for the fourth, fifth, and sixth grades. According to the findings, there was not much extraneous cognitive load (ECL) resulting in the course method. Because of the intricacy of the subject, the Extraneous Cognitive Load (ECL) increased during curriculum analysis.

Novak et al. (2018) conducted research measuring intrinsic cognitive load and extraneous cognitive load correlated with human learning in non-digital environments. The researcher adapted Leppink and colleagues' cognitive load questionnaire to measure the intrinsic and extraneous cognitive complexity of e-textbook learning. The samples of Undergraduate (UG) biology 1337 students participated in an online questionnaire, which included e-text cognitive load questions and questions about their preferences and attitudes toward e-textbooks. The result of exploratory and confirmatory factor analyses yielded some support for using two intrinsic cognitive load constructs and extraneous cognitive load with e-textbook learning. The tool validity was established using an analysis of the relationships between intrinsic cognitive load and extraneous cognitive load and students' academic achievement, e-text preferences, and attitude measures. Reading off a screen and navigating and manipulating e-texts were among the factors negatively correlated with e-text extraneous cognitive load.

Josephsen, (2018) investigated implementing a (WOM) worked-out modelling pre-briefing intervention on post-simulation knowledge acquisition and cognitive load experienced. The analysis was a quasi-experimental quantitative design. The convenience sampling technique was adapted to 61 senior-level nursing students who had previously participated in a simulation. The treatment group received the (WOM) worked-out modelling intervention before simulation participation, and the control group received the usual pre-simulation interventions. A pre-simulation and post-simulation knowledge survey and a cognitive load (CL) measurement instrument were administered after the simulation. The result indicated improved knowledge related to falls and background, situation, assessment, and recommendation in the treatment

group (TG) and suggested that the treatment group (TG) experienced more intrinsic and germane loads and less extraneous load.

Hadie et al. (2018) investigated the impact of a new lecturing guideline, the Cognitive Load Theory-based Lecture Model (CLT-bLM), on students' cognitive engagement and motivation. The total samples are 197 participants from three institutions. The control group attended freestyle lecturing, and the intervention group attended (CLT-bLM-based) lecturing on the same topic. Three weeks after that, the lecturers had participated in a CLT-bLM workshop that allowed them to prepare for the CLT-bLM-based lecture for three weeks. The students' ratings on their cognitive engagement and internal motivation were evaluated immediately after the lecture using a validated Learners' Engagement and Motivation Questionnaire. The intervention group has a significantly higher cognitive engagement level than the control group. However, no significant difference in internal motivation scores was found in both groups. Also, the intervention group reported having a good learning experience from the lectures. The guideline successfully stimulated students' cognitive engagement and learning experience, which indicates a successful stimulation of students' germane resources. Stimulation of these cognitive resources is essential for successful cognitive processing. Its result concludes that (CLT-bLM) based on the lecture method reduces the Extraneous cognitive load and manages the intrinsic cognitive load, allowing for the freedom of working memory resources.

Nurjanah and Retnowati (2018) focused on extraneous cognitive load in the 7^{th} Std. mathematics textbook from Indonesia. By analysis, the most found extraneous cognitive load are the split–attention effect, redundancy, lack of singling, and typing mistakes, etc., the result of the textbook presented a high percentage of lack of singling and typing mistakes, creating the students' difficulty understanding the concept. The study suggested that instructional designers should avoid presenting the same information differently and add an outlining sentence that lists the main steps, headings, numbering and the other signals to reduce the extraneous cognitive load on the textbook The result of the textbook presented the high percentage of lack of singling and type mistake, it may be cases of students' difficulty understanding the concept.

Seufert (2019) looked at whether pre-training can effectively teach strategies for integrating text and pictures and whether learners' existing domain-specific knowledge affects the training's benefits. The study's main premise was that learners' past knowledge would influence how effective such training was, with higher prior knowledge learners benefiting more from it. An initial three-week training period was followed by an introduction to processing, integrating, and reflecting on texts and images. The study (N = 30) examined how the training affected recall and understanding compared to the no-training group, which got a different kind of instruction unrelated to text-picture integration. Regression analysis revealed that the integration training only benefited learners with higher levels of prior knowledge, not everyone.

Singh et al. (2019) conducted a study to evaluate the impact of the augmented reality learning environment on the electronics laboratory skills of engineering students. The major objective of the study was to determine the impact of Augmented Reality intervention on students' laboratory skills, cognitive load, and learning motivation. The experimental design was chosen by the researcher. The experiment was conducted amongst 60 (30 experimental + 30 control) first-year undergraduate engineering students. The participants were selected by the convenient sampling technique. The participants were randomly divided into two groups: The experimental group and Control group. The participants of the experimental group were given Augmented Reality Learning Experience treatment while the participants from the control group were given traditional teaching treatment. The survey questionnaire for measuring cognitive load was adapted from the questionnaire developed by Hwang et al. The result has revealed that AR intervention has a significant positive impact on student laboratory skills. Also, ARLE is an effective tool in reducing the cognitive load of students while operating laboratory equipment.

Costley et al. (2020) discussed extraneous cognitive load and germane cognitive load. Managing extraneous cognitive load is through specific video lecturing to improve learning. It analyses survey responses from students participating in online classes on the mediating effect of video lecturing viewing strategies on the relationship between extraneous cognitive load and germane cognitive load. The major hypotheses were Extraneous load is negatively correlated with germane load. Participants were 2012 students from the Open Cyber University who were selected by random sampling.

Descriptive survey research was used in the present study. The questionnaire was used to collect data. Regression analysis and correlation analysis applied for analyzing the data. The result showed a large negative correlation between the extraneous cognitive load (ECL) and (GCL) germane cognitive load. But viewing strategy mediated the relationship between both when it combined with the model relationship shift towards positive correlation.

Li et al. (2021) investigated on how learning achievement was affected by a Two-tier Test Gaming (CM-TTG) approach based on Concept Mapping. To be more precise, idea maps were used as learning strategies to raise students' learning achievement, and the two-tier test was used as a diagnostic tool for learning. A quasi-experimental design was used to compare the learning achievement, learning motivation, flow experience, and cognitive loads of ninth-grade students using the CM-TTG approach versus those using the traditional two-tier test-based gaming approach to determine the efficacy of the proposed approach. Additionally, behavioral patterns of both the experimental and control groups using the various approaches, as well as low- and high-achievers in the CM-TTG, were analyzed. ANCOVA was used to analyze the data. The study's findings demonstrated that the concept-mapping technique, when combined with the two-tier exam digital game-based learning, could greatly raise students' learning outcomes. The two groups' cognitive loads, flow experiences, and learning motivation did not differ significantly. Furthermore, the learning motivation and flow experience average scores for both groups were higher than 3.0, whereas the cognitive load ratings were lower than 3.0. It is concluded that the students' cognitive load, motivation to learn, and flow experience were not significantly affected by the CM-TTG technique.

In a virtual reality learning environment, **Albus and Seufert (2023)** examined the effects of extra instructional text mode (visual-only vs. audio-visual) on learning outcomes and cognitive load. For achieving the objectives of the study researcher adopted the experimental design. 61 students (of the age group 19 to 37) were selected by the purposive sampling. Higher learning outcomes are achieved overall when verbal information in virtual reality is delivered auditorily rather than graphically. We hypothesized no differences in intrinsic cognitive load for the audio-visual condition, but higher germane cognitive burden and lower extraneous cognitive load. ANOVA was applied for the data analysis. The results, however, indicate a

reverse modality effect. Recall, comprehension, and transfer learning outcome scores were higher in the visual-only group. The conditions did not differ in terms of the inherent cognitive burden, as was to be expected. We did not discover any variations in superfluous cognitive load, though. In contrast to what we had predicted, we discovered a higher relevant cognitive load in the visual-only condition than in the audio-visual condition. This finding could be explained by self-control techniques such as repeated reading or other reading tactics.

Seufert et al. (2024) investigated a study with the purpose is to validating the hypothesis, which holds that learner resources and cognitive load operate as mediators in the inverted U-shaped link between task difficulty and self-regulatory actions. The sample was drawn with the help of purposive sampling. Sixty-seven individuals in the within-subject study reported using cognitive and metacognitive strategies for four exams of different levels of difficulty. Exam task difficulty, cognitive burden, and resources (previous knowledge, interest, etc.) were measured for each task. An inverted U-shaped link between task difficulty and the application of cognitive techniques was found using multilevel analysis. There was just a linear association observed for metacognitive methods. These relationship patterns were mediated by an increase in cognitive load. We discovered competitive mediation for learner resources, suggesting that more mediators might be pertinent.

2.2.1 OBSERVATIONS

There were total twenty studies reviewed by the researcher in which one study (Singh et al., 2019) was conducted in India rest of the 19 studies (Amadieu et al., 2009; Lee, 2013; Liang & Lai, 2013; Figen, 2014; Andrade et al., 2015; Akkaraju, 2016; Hadie & Yusoff, 2016; Turan & Goktas, 2016; Klepsch et al., 2017; Permana et al., 2017; Novak et al., 2018; Josephsen, 2018; Hadie & Zul, 2018; Nurjanah & Retnowati, 2018; Seufert, 2019; Costley et al., 2020; Li et al., 2021; Albus & Seufert, 2023; Seufert, 2024) were conducted abroad.

The research designs were true-experimental (Liang & Lai, 2013; Andrade et al., 2015; Albus & Seufert, 2023) and quasi-experimental (Amadieu et al., 2009; Lee, 2013; Figen, 2014; Akkaraju, 2016; Turan & Goktas, 2016; Permana et al., 2017; Josephsen, 2018; Hadie & Zul, 2018; Seufert, 2019; Li et al., 2021;), descriptive study (Novak et al., 2018; Costley et al., 2020), cross-sectional study (Hadie &

Yusoff, 2016), developmental study (Klepsch et al., 2017), correlational study (Seufert, 2024).

The sampling techniques were random sampling (Lee, 2013; Liang & Lai, 2013; Andrade et al., 2015; Novak et al., 2018; Costley et al., 2020), Purposive sampling (Figen, 2014; Akkaraju, 2016; Turan & Goktas, 2016; Permana et al., 2017; Li et al., 2021; Albus & Seufert, 2023; Seufert, 2024), Convenient sampling (Amadieu et al., 2009; Josephsen, 2018; Singh et al., 2019).

Tools used to collect data were self-reported questionnaire (Amadieu et al., 2009; Lee, 2013; Liang & Lai, 2013; Figen, 2014; Andrade et al., 2015; Akkaraju, 2016; Hadie & Yusoff, 2016; Turan & Goktas, 2016; Permana et al., 2017; Josephsen, 2018; Hadie & Zul, 2018; Nurjanah & Retnowati, 2018; Seufert, 2019; Costley et al., 2020; Li et al., 2021; Albus & Seufert, 2023), online questionnaire (Novak et al., 2018), and Likert Scale (Permana et al., 2017).

Statistical techniques used to analyse the data were Mann-Whitney U (Amadieu et al., 2009), MANCOVA (Liang & Lai, 2013), ANOVA (Andrade et al., 2015; Albus & Seufert, 2023), ANCOVA (Li et al., 2021) t-test (Turan & Goktas, 2016;), MANOVA (Turan & Goktas, 2016;) Confirmatory factor analysis (Hadie & Yusoff, 2016; Novak et al., 2018), regression (Seufert, 2019; Costley et al., 2020), Correlation analysis (Costley et al., 2020; Seufert, 2023)

Findings revealed that cognitive load was reduced through concept map (Amadieu et al., 2009), 3D courseware (Liang & Lai, 2013), Concrete training (Lee, 2013), Storytelling (Figen, 2014), multimedia training (Andrade et al., 2015), filliped learning (Akkaraju, 2016; Turan & Goktas, 2016), workout modelling (Josephsen, 2018), augmented reality (Singh et al., 2019), video lecture (Costley et al., 2020), gaming approach (Li et al., 2021), verbal information in VR (Albus & Seufert, 2023). On the other hand, Hadie and Yusoff (2016) showed that problem-based learning situations increase the cognitive load among learners.

2.2.2 SCOPUS Database Analysis

The following analysis has been done based on the data extracted from the SCOPUS database on the following keywords or search prompt.

TITLE-ABS-KEY:

"(constructiv* AND "cognitive load" AND science) AND PUBYEAR > 2001 AND PUBYEAR < 2025 AND (LIMIT-TO(DOCTYPE, "ar") OR LIMIT-TO(DOCTYPE, "ch"))"

2.2.2.1 Published Document (Year-Wise)

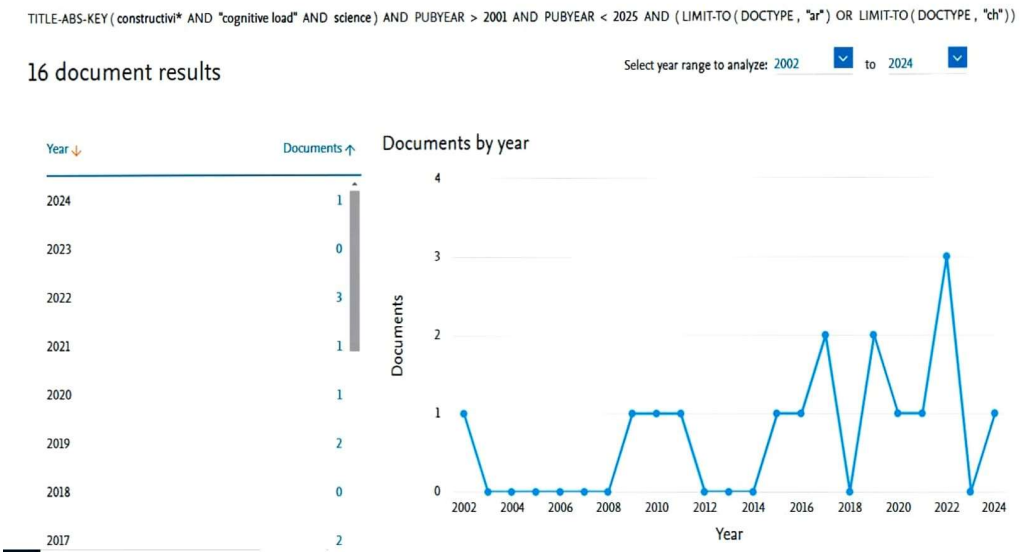

Figure 2.1: Published Document in SCOPUS Database (Year-wise)

Figure No. 2.1 shows the total number of papers published in the SCOPUS database on constructivism and Cognitive load in the science subject. According to the SCOPUS database, only sixteen papers were published till 2024. This data shows a remarkable lack of literature on constructivism and cognitive load theory.

2.2.2.2 Thematic Map analysis

The thematic map (Figure 2.2) in the image categorizes topics within the field based on two key dimensions:

1. **Relevance Degree (Centrality)**: This represents how connected a theme is to the overall research area.
   - Higher centrality indicates a "core" theme that is fundamental and widely discussed.
   - Lower centrality suggests that the theme is more peripheral or specific.
2. **Development Degree (Density):** This indicates the level of research maturity in the theme.
   - Higher density means the topic is well-researched and developed.
   - Lower density points to less maturity or an emerging research area.

2.2.2.3 Observations on SCOPUS Database:

1. Main Cluster (Top Right - "Motor Theme"):

The "learning" is in the upper-right quadrant, indicating high relevance to the overall field. This also suggests that this topic is a relatively developed and significant topic, suggesting that research around "learning" and its implications for "humans" is a core area.

2. Emerging or Marginal Themes (Bottom Left):

The keywords "educational theory" is located in the lower-left quadrant, indicating low centrality and density; this suggests that this is an emerging field with an unexplored area with the cognitive load in the current research framework. This also represents a new or niche area not yet fully integrated into mainstream discourse.

3. Emerging Field of Study:

The map suggests that while "learning" remains a dominant and well-established theme in the field, this is a smaller emerging subfield, such as:

Educational Theory: Applying theoretical frameworks to understand how constructivist learning environments interact with cognitive load theory.

These emerging topics could focus on the following-

- Enhancing teaching methods in specialized disciplines (e.g., education, medical).
- Bridging theoretical concepts with practical applications in pedagogy.
- Investigating how these theories impact diverse learners and environments.

2.2.2.4 Implications for the Present Study:

This thematic analysis suggested how constructivist approaches can optimize cognitive load in real-world educational contexts and extending findings from medical education to education disciplines. It is also suggested for developing frameworks that integrate constructivism and cognitive load theory for learning environments.

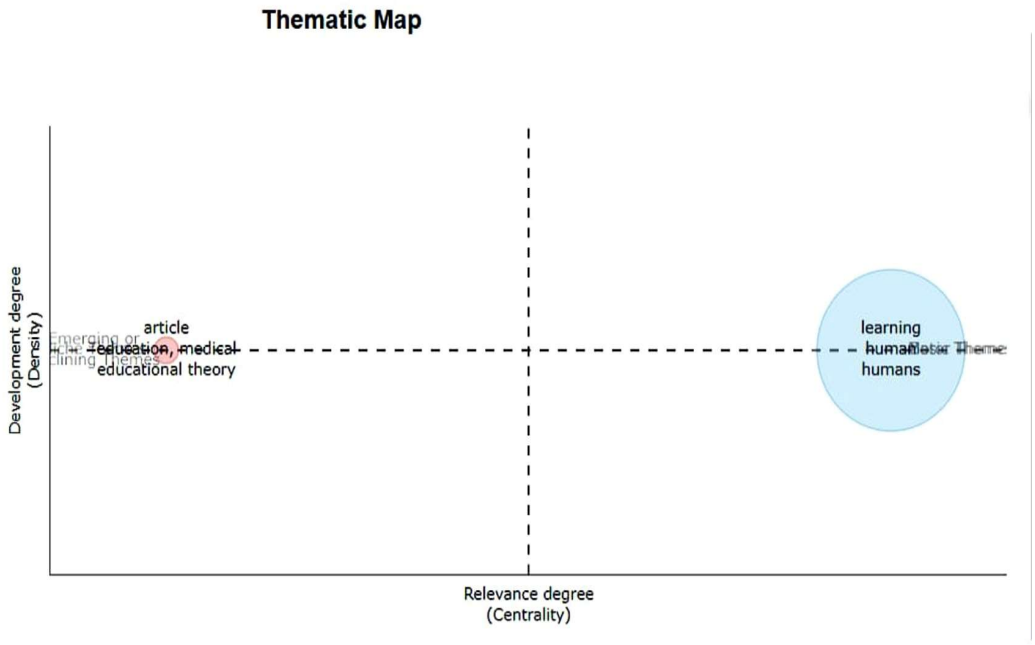

Figure 2.2: Emerging Field of Study (SCOPUS Database)

2.2.2.5 Documents Published (Country-Wise)

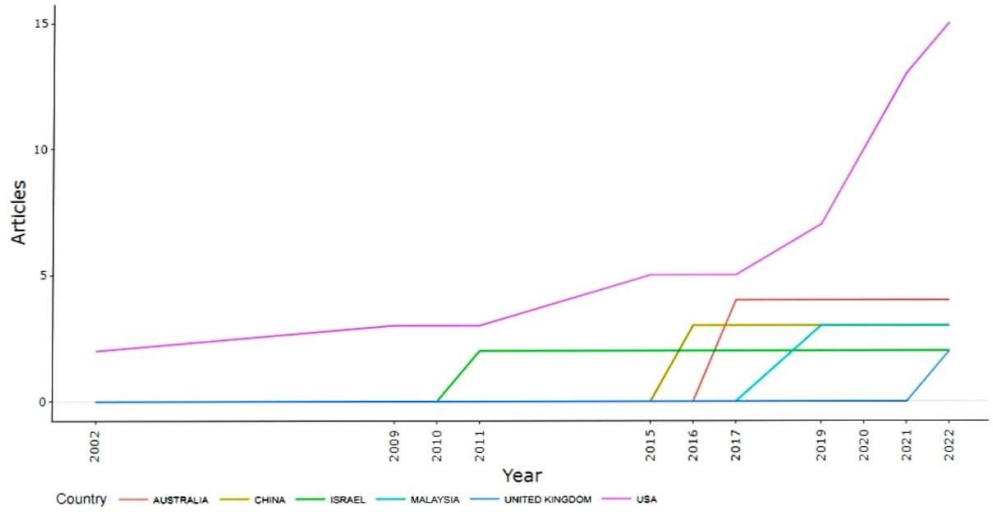

Figure 2.3: Published Document in SCOPUS Database (Country-Wise)

By the bibliometric analysis, the research has found Figure No. 2.3, which shows a trend in the publication of documents in the field of constructivism and cognitive load. This suggests that the United States of America is a leading country, followed by Australia and the United Kingdom. In the Asian continent, only Israel, China, and Malaysia have contributed to the field of constructivism in relation to cognitive load

theory. However, the researcher is unable to find a single paper in this area. From this trend analysis, the research has found insight into framing the present study.

2.3 REVIEWS ON INNOVATION IN LECTURE METHOD

Colthorpe (2007) conducted a study on the second-year physiology course and examined the effectiveness of interactive lecturing in a module of eight lectures on respiratory physiology for two different sub-cohorts of students: those with strong science backgrounds and those without. The questions of interest were 1. Will improved exam scores indicate that students have gained a better comprehension of respiratory physiology as a result of interactive lecturing? 2. Will interactive learning be more beneficial for pupils who typically have less prior scientific knowledge? Through convenient sampling, second-year students of the graduation were selected as the sample of the study. By comparing the results of the summative respiratory physiology exams, we were able to assess the effectiveness of interactive lectures for every subgroup. How students felt about interactive lectures was assessed through formal teaching evaluations. To confirm the results even further, the researchers conducted the study again the next year. For data analysis, t-test and ANOVA were applied by the researcher. Learning results were greatly enhanced by the inclusion of interactive lecturing, and this effect persisted throughout the study time. Moreover, learners with little prior knowledge, who had previously scored extremely poorly in this module, achieved a learning outcome that was comparable to that of learners with strong science backgrounds.

Baragoona (2009) conducted a study on Multiple intelligences and alternative teaching strategies: The effects on student academic achievement, conceptual understanding, and attitude. The purpose of this study was to investigate the interactions between multiple intelligence strengths and alternative teaching methods on student academic achievement, conceptual understanding, and attitudes. The design was a quasi-experimental study, in which students enrolled in Principles of Anatomy and Physiology, a developmental biology course, received lecture-only, problem-based learning with lecture, or peer teaching with lecture. These students completed the Multiple Intelligence Inventory to determine their intelligence strengths, the Students' Motivation Toward Science Learning questionnaire to determine student attitudes towards learning in science, multiple-choice tests to

determine academic achievement, and open-ended questions to determine conceptual understanding. Effects of intelligence types and teaching methods on academic achievement and conceptual understanding were determined statistically by repeated measures ANOVA. No significance occurred in academic achievement scores due to lab group or due to the teaching method used; however, significant interactions between group and teaching method did occur in students with strengths in logical-mathematical, interpersonal, kinesthetic, and intrapersonal intelligence. Post-hoc analysis using Tukey HSD tests revealed students with strengths in logical-mathematical intelligence and enrolled in Group Three scored significantly higher when taught by problem-based learning (PBL) as compared to peer teaching (PT). No significance occurred in conceptual understanding scores due to lab group or due to the teaching method used; however, significant interactions between group and teaching method did occur in students with strengths in musical, kinesthetic, intrapersonal, and spatial intelligence. Post-hoc analysis using Tukey HSD tests revealed students with strengths in logical-mathematical intelligence and enrolled in Group Three scored significantly higher when taught by lecture as compared to PBL. Students with strengths in intrapersonal intelligence and enrolled in Group One scored significantly lower when taught by lecture as compared to Problem-based Learning.

Chilwant (2012) conducted a study to differentiate between structured interactive lectures and traditional lectures as teaching methods. The major objective was to ensure lectures that were interactive was superior to those that were traditional. In this study quasi-experimental pre-test and post-test design was used. 75 MBBS students were purposively selected as the sample for the study. Two groups of students were formed: one for an interactive lecture and the other for a traditional lecture. With the exception of the different teaching approaches used for each group, the two groups were identical in every way. Separate sessions of traditional lectures and organized interactive lectures were given to the groups. Both groups received instruction on the same pharmacological topics using these techniques. By administering the questionnaire and conducting a multiple-choice exam on the subjects covered, the impact of these two teaching techniques on the students was assessed. Between the two groups, there was no discernible variation in average MCQ scores. T-test was used to analyze the data. However, the results of the questionnaire supported the

structured, interactive lecture approach. As a teaching strategy, structured interactive lectures could be superior to traditional lectures.

Miller (2013) investigated a study titled “A comparison of traditional and engaging lecture methods in a large, professional-level course”. In this study, Engaging lectures, also known as broken or interactive lectures, consist of brief lecture segments interspersed with "breaks" that could include problem sets, brainstorming sessions, one-minute papers, or open discussions. The use of engaging lectures in undergraduate settings has been found to have numerous positive outcomes; however, there is conflicting evidence in the literature about the use of this learning strategy for professional students. This study's unique design made it possible to compare physiology courses that were both entertaining and instructive with another cohort of 120 first-year School of Dentistry DMD students. This sample was selected by convenient sampling. Traditional lecture methods were used to teach five physiological systems to all students, whereas engaging lecture methods were used to teach six physiological systems. When compared to typical didactic lectures, the usage of engaging lectures resulted in a statistically significant higher average on unit tests (8.6% higher, $P < 0.05$). Additionally, as seen by higher results on the comprehensive final test (22.9% higher in engaging lecture sections, $P < 0.05$), students showed increased long-term recall of the material. Student surveys and evaluations also revealed a number of qualitative benefits, such as a rise in the perceived efficacy of lectures, a fall in interruptions during lectures, and an increase in confidence in the subject matter. Creating interesting lecture activities takes a lot of planning from the instructor and reduces the amount of time that can be spent on standard lectures.

Wolff et al. (2015) in their article titled “Not Another Boring Lecture: Engaging Learners with Active Learning Techniques” mentioned that if we use problem-based learning in the classroom with the lecture method then sessions can be more successful in imparting fundamental knowledge, contextualizing information, and breaking down complex ideas when this strategy are used, which increases learning.

Katyal et al. (2016) investigated a study titled “Enhancing Student's Learning by introducing various Interactive Teaching-learning Methods in the large group”. The major objective was to assess the relative educational effectiveness of interactive

versus didactic lectures and to determine which is the ideal method of instruction for big classes based on faculty and student opinions? Techniques: Over the course of three months, a randomized controlled trial with cross-over was carried out with 112 seventh-semester students at RMCH, Bareilly. Each of the 56 groups received didactic lectures with cross-over and interactive education via Think-Pair-Share, buzz groups, peer instructions, and questioning. MCQs were used in each session's pre-and post-tests. Using the Likert scale, the professors (11) and students (112) completed their feedback. SPSS was used to analyze the data, with P values less than 0.05 being regarded as significant. Results revealed that there was a statistically significant difference ($p < 0.01$) between the two groups' pre- and post-test scores. Furthermore, it was discovered that the increase resulting from the two was statistically significant (p-value <0.001). Students and faculty felt that interactive teaching is a more engaging and effective method of learning for achieving the particular learning objectives in medical education.

Lai and Lee (2016) investigated to find out the effects of using mind-mapping techniques on academic achievement and cognitive load in Engineering Mathematics. Apart from that, the relationship between the cognitive load and academic achievement was also investigated. A total of 28 students were assigned to the experimental group (N=14) and control group (N=14). Academic achievement was measured using post-test and cognitive load was gauged using the NASA-TLX questionnaire. The present research has proven that using mind maps in teaching and learning will significantly improve students' achievement and reduce the cognitive load in Engineering Mathematics. In addition, it has been found that cognitive load is negatively correlated with academic achievement.

Bala et al. (2017) investigated a study titled Effectiveness of Lecture and Smart Class Method of Teaching on Academic Achievements among Upper Primary School Students. This is an experimental study conducted on upper primary school students in the district of S.B.S Nagar, Punjab. The study was conducted on the students of the 6th and 7th classes of an international School. Objectives of this study were 1. To study the difference in the effect of lecture method and smart class method teaching on the academic achievement of upper primary school students. A total of 100 students were enrolled for this experimental study who have met the inclusion criteria and were randomly divided into 2 equal groups by simple random technique. One

group received the lecture method teaching and the other group taught by smart class method teaching. For experiments, the investigator used pre-test and post-test comparison group design. For the collection of data, a structured questionnaire and a structured teaching program have been used by the researcher. t-test was used for the analysis of the data. The results of the study revealed that the lecture method of teaching was more effective as compared to a smart class method of teaching.

Chalak (2017) compared the effects of traditional versus structured didactic lectures (interactive lecturing) on undergraduate students' performance, as well as the effectiveness of different interactive lecture styles. This is an interventional, prospective, single-blind study. A total of 146 first-year MBBS students (73 controls and 73 study participants) took part in all study-related activities. To make each lesson interactive, it was organized and arranged per the didactic lecture technique. A pre- and post-test on the selected subjects was created. A pre-test was administered before the lecture, and a post-test followed interactive instruction. To make the lecture interactive, four strategies were used: assigning questions in a predetermined format, introducing the topic of the day, the muddiest point, and handout distribution, followed by a discussion. The study group participants were given individual lectures on each technique. Data was analyzed with the help of the ‘paired t-test’. The results revealed that the study group's post-test scores significantly improved for each of the four approaches employed, according to the data. When questions were asked in the prescribed format and with the muddiest point, the class average normalized gain—a measure of an educational intervention's efficacy and robustness—was greater than 0.7 (70%) points. In contrast, handouts with the discussion and the point of the day received more than 0.5 (50%) of the vote. In other words, the effectiveness of interactive lecturing approaches for "point of the day" and "handouts followed by discussion" strategies was shown to be modest. Conversely, the use of muddiest points and questions in a prescribed format proved to be highly effective.

Alaagib et al. (2019) investigated a study titled “Comparison of the Effectiveness of Lectures Based on Problems and Traditional Lectures in Physiology Teaching in Sudan”. The major objective of the study was to investigate the effectiveness of the lecture based on the problem (LBP) in comparison to traditional lecture (TL) in teaching physiology. The sample of the study was medical students at the University of Science and Technology. The sampling technique was purposive sampling. for data

collection self self-constructed questionnaire was used by the researcher. Data was analyzed by Z-test and T-test. The results revealed that in LBP the students have better attention (P = 0.002) and a more active role (P = 0.003) than in TL. A higher percentage of students think that LBP stimulated them to use references more (P = 0.00006) and to use the lecture time more effectively (P = 0.0001) compared to TL. However, there was no significant difference between LBP and TL in the awareness of the learning objectives. About 64% of students think that LBP was more enjoyable and it improved their understanding of physiology concepts. The comparison of the students' quiz marks showed that the means of the student's marks in the introduction to physiology and respiratory courses were higher in the quizzes of LBP than in TL with a significant difference between them ((P = .000), (P = .006) respectively.

Nguyen (2024) investigated a study in Finland titled "The Effects of Short Online Pedagogical Courses on University Teachers' Conceptions of Learning and Engaging Students During Lectures". The purpose of this study is to investigate how short online pedagogical training courses affect university instructors' perceptions of active learning from two angles: the importance of prior knowledge and keeping their students engaged during lectures. Questions of interest were 1. How did educators' perspectives on the value of past knowledge and interesting lectures change following a brief online pedagogy course? 2. Which teacher groups benefited most from the brief online pedagogical course in terms of their prior pedagogical training and teaching experience? The sample of the study was 108 Finnish University teachers and doctoral students. 'Pre-test and post-test design' was applied in this research. Self-reported surveys were used to gauge the training's impact. The findings demonstrated a decline in the notion that learning was merely remembering and an increase in the participants' assessments of the significance of prior information in the learning process. By the end of the classes, there was also a greater awareness of the need to create interesting lectures. These results show that short pedagogical courses were beneficial for developing pedagogy, particularly for university instructors who have never taken a pedagogy course before.

2.3.1 OBSERVATIONS

There were a total of twenty studies reviewed by the researcher, of which two studies (Katyal et al., 2016; Bala et al., 2017) were conducted in India rest of the 9 studies

(Colthorpe, 2007; Baragona, 2009; Chilwant, 2012; Miller, 2013; Wolff et al., 2015; Lai and Lee, 2016; Chalak, 2017; Alaagib et al., 2019; Nguyen, 2024).

The research designs were true-experimental (Katyal et al., 2016; Lai and Lee, 2016; Bala et al., 2017) and Quasi-experimental (Colthorpe, 2007; Baragona, 2009; Chilwant, 2012; Miller, 2013; Chalak, 2017; Alaagib et al., 2019; Nguyen, 2024), review study (Wolff et al., 2015).

The sampling techniques were random sampling (Katyal et al., 2016; Lai and Lee, 2016; Bala et al., 2017; Chalak, 2017), purposive sampling (Baragona, 2009; Chilwant, 2012; Alaagib et al., 2019), and convenient sampling (Colthorpe, 2007; Miller, 2013).

Tools used to collect data were a questionnaire (Colthorpe, 2007; Chilwant, 2012; Miller, 2013; Katyal et al., 2016; Lai & Lee, 2016; Bala et al., 2017; Chalak, 2017; Alaagib et al., 2019; Nguyen, 2024), a self-reported survey (Nguyen, 2024) inventory (Baragona, 2009), Likert scale (Katyal et al., 2016).

Statistical tests used to analyze data were t-test (Colthorpe, 2007; Chilwant, 2012; Miller, 2013; Katyal et al., 2016; Lai & Lee, 2016; Bala et al., 2017; Alaagib et al., 2019), paired t-test (Chalak, 2017), z-test (Alaagib et al., 2019), and ANOVA (Colthorpe, 2007; Baragona, 2009).

Findings revealed that the interactive and engaging lecture improve the learning and understanding of concepts (Colthorpe, 2007; Chilwant, 2012; Miller, 2013; Katyal et al., 2016; Bala et al., 2017; Chalak, 2017) lecture give more favourable results with the combination of the mind map (Lai & Lee, 2016), problem-based (Wolff et al., 2015; Alaagib et al., 2019).

2.4 IMPLICATIONS OF REVIEW OF RELATED LITERATURE

The researcher reviewed a total of ninety-one studies. Sixty studies were on Constructivism, twenty studies on cognitive load, and eleven studies on innovation in the lecture method. By reviewing the studies, the researcher found many studies related to constructivism such as Constructivism has been a positively significant method for teaching biology (Mohapatra & Kumari, 2015; Kumar, 2016; Sandhu, 2017), teaching science (Shukla, 2016), teaching science through cooperative learning strategy (Yaduvanshi & Singh, 2018), teaching of science through 7Es model (Adak, 2017), chemistry learning (Huseyin et. al. 2003). Secken and Alsan (2011) found that constructivism was a beneficial approach to teaching and learning the concept of

hydrolysis in chemistry. Chawdhuri (2016) found that this approach has a significant positive effect on mathematics achievement, and understanding and applicability have been enhanced. Pangat (2017) found that this approach significantly positively affects mathematics achievement and enhances reflective ability. Loyens et al. (2006) suggested constructivism helps in developing problem-solving ability, while Kroesbergen (2004) found the constructivist approach has less impact on mathematics learning than the explicit method.

Science teaching should be through activity-based pedagogy because the attainment of the objectives of science teaching is possible through activity-centred pedagogy. As we saw, the constructivist approach provides scope to the learners for activity and construction of knowledge based on previous experiences; therefore, the National Curriculum Framework (2005), the National Education Policy (2020), the National Curriculum Framework for School Education (2023) advocated for adopting activity-based pedagogy and constructivism for science teaching but through constructivism completion of the subject is not possible therefore teacher have a moderate attitude to adopt constructivism in classroom. On the other hand, the lecture method makes the classroom monotonous. However, previous research showed that interactive lectures and lectures with problem-based pedagogy and mind maps improved learning among the learners. The investigator came across 60 studies done on the constructivist approach, most of which were related to developing strategies based only on the constructivist approach. However, the researcher found few studies that incorporated constructivist strategies in the lecture method, so the researcher wants to develop a pedagogical intervention by incorporating constructivist strategies in the lecture. As a result, the disadvantages of both pedagogies are overcome with the advantages of both types of pedagogy. In this continuum, the researcher finds the study related to examining the effect of constructivism on the teaching of science, biology, chemistry, the education system, motivation, problem-solving, flexibility in thinking, reflective thinking, reasoning skills, and mathematics learning. The researcher also found that mind maps and concept maps, the cognitive load theory-based lecture method, help in reducing the cognitive load among the learners. After analyzing the SCOPUS database and reviewing the literature, the researcher felt a scarcity of research evidence that shows the effect of the constructivist approach on the cognitive load of students. For the present study, the researcher chose class ninth-grade students because these students fall under the age range of 13-16, which is crucial for

developing critical thinking and rational thinking. At this stage, abstract thinking is also developing in the students; therefore, for the present study, this age group of students was more appropriate. In this study, the researcher tried to investigate the effect of the intervention programme based on constructivist strategies on the cognitive load of secondary students in the science subject.