

Effect of Animated Instructions on Elementary Students' Conceptual Knowledge in Science

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Abstract

The purpose of the study is to compare the effects of the lecture method and animated instructions on the conceptual knowledge of fifth-grade science students. It is experimental in nature, and a true experimental design was used. The population consists of fifth-grade science students enrolled in a government girls' school in District Gujrat. One public school was selected, and 28 students were taken as the sample for the study. Control and experimental groups were formed through random assignment. The control group was taught using the lecture method, while the experimental group was taught using animated instructions, both over a period of one month. A test was developed by the researcher to measure students' conceptual knowledge gained through the lecture method and animated instructions. The tool was validated through expert opinions. Data were collected and analyzed by comparing the mean gain scores of the pre-test and post-test. An independent sample t-test was used for this purpose. There is a significant difference in the mean gain scores of students taught through the lecture method and those taught using animated instructions. This study aims to raise awareness about the importance of animated instructions and to provide guidance for teachers, suggesting that animations can be effectively used in schools to improve science teaching and enhance students' understanding of science concepts.

Keywords: Animated instructions, conceptual knowledge, science, elementary students

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Introduction

The teaching profession is considered the backbone of the society. It has great importance in shaping the society. It gives trained teachers to the nation (Kamran et al., 2015). The selection of a suitable instructional strategy ensures that the defined learning objectives are effectively achieved. The most popular teaching method is the lecture-based approach. This technique involves the teacher reading a significant portion of the course material before the students arrive and then providing clarification to ensure their understanding (Kantar & Salian, 2018). This method is used to help students grasp key concepts and primarily focuses on content delivery. Information is often presented in small, distinct segments that collectively form a larger concept. The teacher's main objective when using this strategy is to deliver knowledge and information to passive learners.

According to Uden (2006), students are expected to sit quietly, listen to the teacher, and take notes in a lecture-based learning environment. A teacher can educate a large class using this method. It is the students' responsibility to memorize the material presented in the lectures. In Pakistan, a developing nation, lectures are widely used at all academic levels to teach various subjects (Faize, 2011).

The word "animation" refers to images that appear to move. Animations are commonly used to demonstrate phenomena that are difficult to observe in the real world. Hummell and Harrison explained that a series of still images shown in quick succession can create the illusion of motion. According to Brown, Lewis, and Harclerod, animations are motion-based visuals created from images that seem to move when projected. They are among the most well-known types of graphical representations. Incorporating animations into instructional materials can help create a more productive learning environment. Using animation in lectures benefits both visual and verbal learners (Rieber, 1991).

Animations support a variety of learning methodologies in science classrooms. Conceptual knowledge is closely linked to the application of information and skills. Along with effective teaching and learning strategies, instructional resources can enhance students' understanding of textbook content. Conceptual knowledge accelerates learning and results in the formation of facts, classifications, categories, generalizations, principles, and theoretical models and structures.

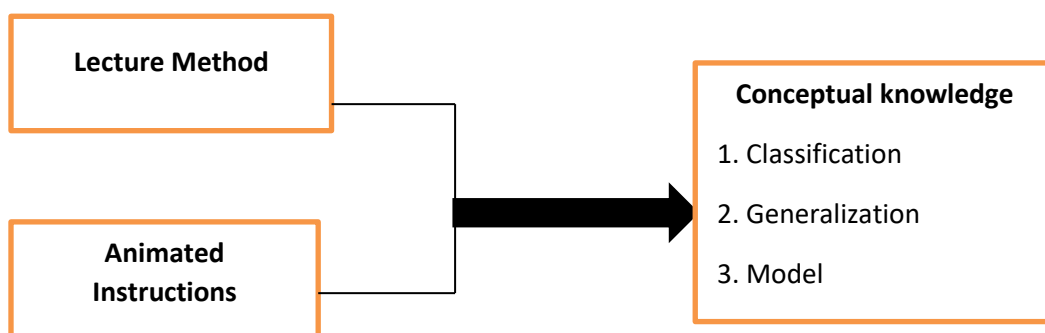


Figure 1: Conceptual Framework

Lectures may focus more on surface-level understanding of scientific principles rather than promoting in-depth comprehension. In contrast, more dynamic and engaging learning experiences can help students retain information more effectively. Animation can make complex scientific ideas easier to understand for a wider range of students. By placing scientific concepts in real-world contexts, animation makes them more relevant and meaningful. Integrating animation into science classes can lead to deeper understanding, improved memory retention, and the creation of more interactive and stimulating learning environments.

Literature Review

The main objective of citing relevant sources is to assist in organizing, refining, and understanding different concepts related to the topic under study. The literature review

significantly contributes to the development of the conceptual framework and theory of change by identifying gaps that need to be addressed to resolve the issue at hand.

Teaching and learning go hand in hand in the field of education. Education is a tool designed to equip students with the knowledge and skills they need to be prepared and empowered. Since many students perform poorly academically when teaching strategies are inadequate, Adunola (2011) asserts that the effectiveness of a teaching method has a significant impact on student learning. According to Ayeni (2011), the main objectives of teaching are to ensure high-quality education within a specific timeframe and to bring about positive and desired changes in students' behavior. Adunola (2011) further emphasizes that teachers need to be aware of a variety of pedagogical approaches and choose the one that best suits the subject matter. A teacher can cover a wide range of topics using various effective teaching methods, making it easier for students to grasp complex content.

Boyle (2000), Zhenhui (2001), and other researchers note that teachers often tend to prioritize test scoring, teacher-centered classrooms, and content delivery over the development of students' conceptual understanding and critical thinking skills. Students have become accustomed to the lecture method, which remains the dominant instructional approach used by teachers to deliver the curriculum (Zhenhui, 2001). In Pakistan, a developing country, lectures are widely used at all educational levels to teach a variety of subjects. It is the responsibility of students to retain the knowledge imparted by teachers during these lectures (Christie & Afzaal, 2005).

In the increasingly globalized world, science and technology are drastically transforming people's worldviews and lifestyles. As a result, countries are focusing on producing skilled individuals and cultivating a qualified and developed workforce. In the twenty-first century, a variety of essential skills have gained importance, including critical thinking, multi-criteria decision-making, stress management, digital literacy, and both introspective and creative thinking (Ayyıldız & Yılmaz, 2021).

Moreover, it is well-known that teaching methods such as simulation, animation, digital technology-based training, and visits to scientific centers have high retention rates and long-lasting learning effects (Demirkan, 2019). Animation is often used in films to captivate audiences and has shown significant educational benefits for younger viewers. This may be why Thompson (2010) suggested that animated films include visuals that can engage and hold the attention of young audiences while also promoting learning and development. It is clear that the influence of technology on daily life has extended to educational programs and processes, making the integration of technology-based applications in classrooms increasingly essential (Conejar & Kim, 2014; Eryaman, 2007).

The twenty-first century is often referred to as the "digital age" or the "era of digital applications." Animations are believed to aid students in better understanding complex concepts. This is partly because animations reduce cognitive load and are engaging, helping students visualize the material being taught (Ainsworth, 2008). Rosen (2009) explored the effects of animation-based learning environments on knowledge transfer, motivation in science, and mastery of concepts. Furthermore, animation can depict unique processes and imaginative

scenarios, such as the detailed movement of atoms and molecules, which enhances the understanding of scientific ideas (Yılmaz & Bayrakçeken, 2017).

Some researchers believe animations support learning because of their engaging nature (Rieber, 1991). They argue that certain algorithmic features of animations align with the cognitive needs of educational tasks (Tversky et al., 2002). However, others remain skeptical and caution against their use. Critics often highlight the challenges students may face in interpreting animations correctly or applying them effectively (Lowe, 2003). Nevertheless, a study by Barak, Ashkar, and Dori (2011) found that students' understanding of scientific concepts and their ability to explain them improved after viewing animated films.

Variations in the cognitive properties of the two representation formats may not be the primary reason for animation's advantages over static depictions (Cheng, Lowe, & Scaife, 2001). The advantage of animations lies in their ability to effectively and accurately portray dynamic scenarios, allowing students to focus more of their cognitive resources on understanding the material in real time. However, Tversky, Morrison, and Betrancourt (2002) caution against assuming that animated presentations are inherently superior to static ones, as the representations compared may not convey an equivalent amount of subject-matter information.

According to Barak, Ashkar, and Dori (2011), animation can enhance students' understanding in two main ways. First, it facilitates the conceptual construction of models related to concepts, phenomena, and processes. Second, it supports students who struggle with complex cognitive tasks such as abstraction, creativity, or imagination. The differences between learning outcomes involving retention and problem-solving tasks using dynamic versus static visuals have been widely researched. Specifically, learning with animations is expected to improve understanding and, consequently, enhance complex problem-solving abilities. In this context, animation serves as an external model of mental representation. Students are more motivated to learn when engaging animations are used instead of traditional teaching methods (Cevahir et al., 2022).

Concepts are the foundational building blocks of ideas. According to Ausubel (1968), concepts act as cognitive filters that help individuals perceive and understand the world. Shumway, White, Wilson, and Brombacher (1983) suggest that learning comprises three key elements: problem-solving, concept learning, and skill development. Concept learning requires the ability to abstract, generalize, classify, and form connections between symbols and their referents (Lovitt, 1989). Students with underdeveloped conceptual skills may find it difficult to create new ideas in real-life contexts. The primary goal of concept learning is to provide structured information about a specific element or group of elements and help learners distinguish them from others (Klausmeier, 1976).

According to Westwood (2008), a concept is "a mental representation that embodies all the essential features of an object, a situation, or an idea." We may categorize things into groups that they either belong to or do not belong to thanks to concepts. According to Chinn (2012), concepts are traits that establish whether or not something belongs to a set or class. The emphasis is on labelling, classifying, categorizing, and arranging. From the physical to the abstract, concepts can take many different forms. Each concept has unique characteristics that distinguish

it from the others. Moreover, these characteristics make the concept challenging (Tennyson & Cocchiarella, 1986). Higher order cognitive functions including classification, reasoning, planning, and analogical thinking all involve concepts (Machery, 2009). Concepts gradually combine smaller ideas to form larger structures (Danks, 2014). We retain ideas in our minds as fragments of knowledge that we use to comprehend more complex ideas (Machery, 2009). The ontological shift method maintains that concepts reflect the traits of every group member and has a close relationship to concept theories (Goldwater and Schalk, 2016). We must assess how well students use scientific concepts, how they form conclusions, and how well they understand those concepts in order to assess how well they are learning (Rusanen & Pöyhönen, 2013). The process of organising relevant ideas, facts, attitudes, and skills to build a logical cognitive link that makes it easier to transmit, store, assimilate, and retrieve concepts for application in both familiar and unfamiliar contexts is known as conceptual knowledge. Conceptual knowledge includes identifying patterns in data, making connections between ideas, understanding concepts more thoroughly, promoting personal relevance, and applying concepts to desired situations. The conceptual approach seeks to enhance students' cognitive abilities by organizing a conceptual map and providing a conceptual approach to education. Benefits of conceptual knowledge include enhanced synthesis and analysis, enhanced problem-solving abilities, the ability to apply theory to practical contexts, the promotion of both linear and non-linear cognitive processes, and the creation of new concepts (Fletcher et al., 2019). Through problem-solving, critical thinking, and conceptual understanding products, students' interest and motivation in remembering, understanding, applying, analysing, evaluating, and producing science concepts are developed (Ulina, 2017). Science classes help students strengthen their scientific thinking, scientific interpretation, problem-solving, and communication skills (Ulina, 2017). Conceptual knowledge is essential to learning in general and science-related learning in particular, claims Anderson et al. (2001). Understanding a scientific topic necessitates investigation, explanation, and interpretation. As stated by Riley-Johnson, Siegler, and Alibali (2001), it comprises knowing "of the principles that govern a domain and of the interrelations between units of knowledge in a domain." Inaccurate and flawed concepts can lead to conceptual misunderstandings and disputes with scientific assertions or understanding (Gurel, Eryılmaz & McDermott, 2015).

Teachers can select various teaching activities for both the assessment and instruction phases and restructure the educational process with the help of the Revised Bloom's Taxonomy (RBT). RBT serves as a model that educators can use to support students' intellectual development (Pickard, 2007).

Table 1: Dimensions of Revised Bloom's Taxonomy

Knowledge Type	Description
Factual Knowledge	Basic facts, terms, and elements.
Conceptual Knowledge	Relationships, categories, and generalizations and models.
Procedural Knowledge	How to perform tasks and methods.
Metacognitive Knowledge	Thinking about thinking, self-regulation, and strategies.

Research Design

This study was experimental in nature and aimed to compare the effects of two teaching methods on the development of conceptual knowledge among fifth-grade students in General Science. The independent variable was the teaching method; lecture method versus animated instruction, while the dependent variable was conceptual knowledge. The population consisted of fifth-grade students from Government Girls Primary School Bhadana, District Gujrat. A sample of 28 students was selected using random sampling. The sample was divided into two equal groups: 14 students in the experimental group and 14 in the control group. The experimental group was taught using animated instruction, while the control group was taught using the lecture method. A randomized pretest-posttest control group design, recommended for small samples (Fraenkel & Wallen, 2012), was employed.

Table 2: Randomized Pretest Posttest Control Group Design

Group	Pretest (O_1)	Treatment (X/C)	Posttest (O_2)
Experimental Group (R)	Conceptual Knowledge Test	X = Animated Instruction	Conceptual Knowledge Test
Control Group (R)	Conceptual Knowledge Test	C = Lecture Method (No Animation)	Conceptual Knowledge Test

In this table R represents the random assignment, X is used to represent the experimental group and C is used to represent the control group.

Research Treatment

The control group was taught using the lecture method, while the experimental group received animated instructions. The treatment was provided for a period of one month, excluding the pretest and posttest days. In alignment with the Single National Curriculum, the material taught was selected from three chapters of the fifth-grade General Science textbook. Specific lesson plans were created for both teaching groups. To enhance students' conceptual understanding, the researcher utilized animated instructions for the experimental group. In the classroom, animations were integrated into each lesson plan for the experimental group. Discussions were held after the animations to ensure a thorough understanding. The researcher assessed the efficacy of the treatment using a pretest and posttest to measure knowledge. Since the subjects were fifth-grade students, the learning objectives for this age group were often met in shorter class sessions.

Expert opinions were sought to ensure the validity of the conceptual knowledge test. Fourteen experts, including science teachers and MPhil scholars from the University of Gujrat's Department of Education, provided feedback. After entering the expert opinion data into an MS Excel sheet, the Content Validity Ratio (CVR) for each item was calculated. In collaboration with the supervisor, some adjustments were made. Eight statements were removed from the instrument due to their extremely low CVR values, and two statements were rephrased. The Content Validity Index (CVI) for the test items was found to be 0.81. A pilot test was conducted with 30 students to assess the instrument's reliability. After entering the collected data into SPSS

software, a reliability test was performed. The test yielded a significant Cronbach's Alpha of 0.72, indicating that the test was reliable.

Results And Discussion

The study investigated the effect of animated instructions versus the lecture method on the development of conceptual knowledge in general science. The results revealed that animated instructions outperformed the lecture method. The mean gain scores of students taught through animated instructions were significantly higher compared to those taught via the lecture method. This substantial difference indicates that students who received instruction through animation performed better than those who were taught using the traditional lecture method. The findings show that the experimental group's mean gain scores differed significantly ($p < .05$). Overall, the study demonstrated that animation is an effective tool for enhancing students' conceptual understanding.

Table 3: Comparison of Mean Gain Scores for Experimental and Control Groups Across Levels of Conceptual Knowledge

Level	Group	N	Mean Gain	S.D.	df	t-value	Sig
Overall	Experimental	14	21.5	5.7	26	3.91	.01
	Control	14	13.2	5.4			
Classification	Experimental	14	8.1	2.1	26	2.10	.03
	Control	14	5.8	3.4			
Generalization	Experimental	14	7.2	2.7	26	3.03	.05
	Control	14	4.0	3.4			
Model	Experimental	14	7.0	4.2	26	3.03	.01
	Control	14	3.0	3.3			

Mayer's (2002) cognitive theory posits that the visual, pictorial, and auditory-verbal cognitive channels are used to represent and process knowledge. The animated films used in this study incorporated elements from both of these networks. The written content and animated characters engaged the visual-pictorial channel, while the use of sight, hearing, and touch, as well as the visual, auditory, and kinesthetic learning styles, were all utilized by students learning through animations. Consistent with previous multimedia research (Dori, Hult, Breslow, & Belcher, 2007; Garcia, Quiros, Gallego, Martin, & Fernandez, 2007), this study demonstrated that using multiple senses to process information facilitates meaningful learning. L2 learners are encouraged to actively process material within these channels by selecting relevant words and images, organizing them into logical verbal and graphical models, and integrating them with existing mental knowledge. According to Mayer (2001), participants perform best when they select both textual and visual information; performance is at its lowest when they rely on only one modality. Similar findings were reported by Yoshii and Flaitz (2002) and Chun and Plass (1996). The cognitive load theory is based on the idea that working memory has limited capacity. Animations that effectively utilize both the visual and auditory channels enhance working memory (Mayer et al., 2001; Sweller, 1994; Mayer & Anderson, 1992). However, excessive

irrelevant or unclear content in an animation can impair both short-term and long-term memory recall. Therefore, this issue lies at the heart of many features that make animation a beneficial tool for teaching.

Conclusions

In the field of general science, students who received instruction via animated methods demonstrated a greater clarity in conceptual understanding ($M=21.5$) compared to those who received traditional lecture instruction ($M=13.2$). This shows that, compared to the lecture method, the use of animated instructions in the classroom has a significant impact on students' mean gain scores on conceptual knowledge tests. Therefore, using animated instructions to teach science in primary schools is more effective in producing the desired outcomes in terms of conceptual knowledge development.

At the classification level of conceptual knowledge, students taught through animated instructions showed a significant improvement, as evidenced by the higher mean value ($M=8.1$) and statistically significant results of the mean gain scores compared to those taught through the lecture method. These results indicate that students perform better when scientific concepts are taught via animations, as they are able to classify or categorize topics according to their various characteristics.

For students' scores at the generalization level, the computed t-value was 3.03 at $df=26$, with $p<.05$. The mean gain scores of the experimental and control groups differed significantly, indicating that the use of animated instructions in the classroom had a major effect on students' scores at the generalization level of conceptual knowledge. The higher mean value ($M=7.2$) and standard deviation ($SD=4.0$) for the experimental group, compared to the lecture method, further support this finding. Animations help students generalize abstract ideas across different contexts by visualizing them and making them more tangible and understandable.

At the model level, the computed t-value for students' scores was 2.1, with $df=26$ and $p<.05$. The mean gain scores of the experimental and control groups were statistically significantly different. The use of animated instructions in the classroom had a substantial impact on students' mean gain scores at the model level of conceptual knowledge, as shown by the higher mean value ($M=7.0$) and standard deviation ($SD=4.2$) compared to the lecture method. By presenting various functions in a structured manner, animations assist students in understanding and modeling complex systems and processes.

The results demonstrated that animated instructions are more effective, suggesting that school administrators should prioritize them when teaching general science, as they can enhance students' motivation and encourage active engagement with scientific concepts. To accommodate different learning styles, it is important to prioritize animated instructions while also incorporating a blended learning approach that includes lectures, discussions, and other interactive techniques.

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