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International Journal of Curriculum and Instruction 18(2) (2026) 89–97

IJCI
International Journal of Curriculum and Instruction

The Effect of Teaching Contrasting Concepts on Long-term Learning of Science Concepts

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Abstract

The purpose of the current study is to make the concept of inertia comprehensible by examining it in relation to its contrasting and similar concepts and to discuss the effect of introducing contrasting concepts in concept teaching on long-term learning. The study employs a document analysis method. In the study, relevant documents containing the concept of inertia and its contrasting and similar concepts were examined using a descriptive analysis approach. In the study, the claim that supporting conventional concept teaching with a concept pool to be developed may be beneficial is discussed. Explaining concepts and providing appropriate examples through a concept pool strategy that includes main, contrasting and similar concepts may contribute to the permanent learning of the main concept. Moreover, presenting multiple concepts together may enable students to develop an intellectual perspective.

Keywords: Inertia; evolution; science; concept pool; concept learning

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1. Introduction

1.1. Introduction to the problem

Is it possible to make a concept comprehensible by explaining it through its contrasting and similar concepts? Naturally, there is no rule that prohibits or prevents this. However, what kind of benefit might it provide? Reflecting on and discussing this question may be useful for the process of concept teaching. First, a concept is described, followed by an explanation of its critical attributes. Then, well-known examples that possess the characteristics of the concept are presented together with those that cannot be examples for the concept (Erden & Akman, 2025). Explanations are provided regarding any exceptional examples of the concept, if there are any. Following this sequence adhered to in concept teaching, the definitions of contrasting and similar concepts may additionally be provided, along with well-known examples, in order to

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ensure the permanent learning of the concept. Moreover, explaining a scientific concept not only through a contrasting scientific concept but also in conjunction with a contrasting or similar concept may provide learners with a more intellectual perspective. It would be beneficial to select the concept of inertia, one of the concepts of the natural sciences, as the main concept and to continue the discussion based on it.

As known well, any entity that has mass and occupies space is defined as matter (Nasuhoğlu et al., 1983). All matters share common properties such as mass, volume, particulate structure and inertia. It would be useful to explain one of these common properties, the inertia of matter, with understandable and appropriate examples. The tendency of an object to maintain its position, shape, or state of motion can be defined as inertia (Nasuhoğlu et al., 1983; Young & Freedman, 2016). Let us consider the process of a public transport bus slowing down to a stop. It is a common occurrence for a passenger, who gets off before the bus comes to a complete halt, to be thrown forward, stumble and often even fall flat on the ground. Prior to this improper alighting, the passenger is in motion together with the bus. Because the passenger gets off before the motion of the bus ends, and due to the tendency of objects to maintain their state of motion, the passenger stumbles in the direction of the previous motion. The tendency of all matters found in nature to maintain their existing states brings to mind the notion of conservatism in humans. In contrast to this conservative aspect of nature, there is another aspect that can be considered its opposite. Evolution can be considered, initially as the opposite of inertia, as a process that suggests matter may not be able to preserve its existing state, form, or even its existence over long periods of time. The book *On the Origin of Species*, published in 1859 by Charles Robert Darwin, is the first document to provide detailed explanations of the Theory of Evolution, one of the most influential theories in the history of science. In this work, Darwin enriched the realities of nature by combining them with his own observations and discoveries and through the experiments he conducted, the investigations he carried out, and the explanations he provided, he endowed the theory with a robust structure that can be supported from many different perspectives (Bakırcı, 2025).

According to Bermek (2023), evolution can be defined as a long-term developmental process that operates through the repetition of successive, ordered patterns of variation and stages of selection, as seen in examples of biological or cultural evolution and that is generally gradual but also exhibits major changes and transformations occurring over short periods at certain intervals. Cevizci (2000) defines evolution as the development and transformation of something toward a more complex and more differentiated organism or organization through a series of changes and developments occurring gradually within a process of progressive change. From a biological perspective, the same researcher describes evolution as the totality of the transformations that living beings have undergone throughout the history of the Earth, or, in the context of living organisms and their natural environments, as a process of transition from simplicity to complexity and from homogeneity to heterogeneity, derived from empirical observation of living beings and their remains. In another source (TDK, 2019), evolution is described as a continuous process of qualitative and quantitative development over time, not occurring suddenly but progressively. In the same source, evolution in the field of biology is defined as a series of changes and a process of maturation through which the morphological and structural characteristics that distinguish one organism from others develop. Given that inertia is construed as nature's conservative side, it becomes essential to provide definitions for conservatism and its antithesis, revolutionism.

Conservatism is a social and political perspective that is sceptical of reforms, opposes large-scale social transformations, and places great value on a society's traditions. It is also a political ideology that enthusiastically defends capitalism, private enterprise, and free entrepreneurship, emphasizes the importance of an electoral social order and moral discipline, and exhibits a tendency to preserve the status quo, that is, the existing order (Cevizci, 2000). In the same source, revolution is generally described as a radical, rapid, and comprehensive transformation that completely changes the established social order and the structure of the state and society. In another source (TDK, 2019), revolutionism is defined as bringing about rapid, radical, and qualitative change in a particular field.

It is argued that conceptual change does not occur at the expected level in the process of teaching science concepts (Posner, Strike, Hewson & Gertzog, 1982; Osborne, 1995; Yıldız, 2022; Yıldız, 2024). Among the reasons for this is the fact that the language used by teachers may evoke different meanings for students. In general, students use language that is meaningful to students, while teachers use language that is meaningful to teachers (Gunstone & Watts, 1985; Yıldız, 2022; Yıldız, 2024). In short, the difference between everyday language and scientific language is considered one of the reasons for the formation of misconceptions (Yıldız, 2021; Yıldız, 2022). Comparing a scientific concept such as inertia with appropriate scientific or social concepts and revealing their contrasts or similarities may enable students to learn these concepts in a lasting manner. In other words, it may make the language used by teachers meaningful to students. Since the current study anticipates that some scientific concepts can be learned more permanently by students through the explanation of contrasting concepts, it may make significant contributions to the literature.

1.2. Purpose of the Study

The purpose of the current study is to make the concept of inertia comprehensible by examining it in relation to its contrasting and similar concepts and to discuss the effect of introducing contrasting concepts in concept teaching on long-term learning.

2. Method

2.1. Design of the study

The study employs a document analysis method. Qualitative research findings are generally obtained through data collected via interviews, observations and examination of documents (Merriam, 2023). Accessing documents is generally more economical and easier in terms of time and cost, which is why document analysis is often preferred over observation and interviews. The document analysis process makes it possible to identify, analyze and derive useful information from existing documents in order to make informed decisions (Özkan, 2022; Watkins, Meiers & Visser, 2012).

2.2. Data collection

Description can be defined as the written expression of the basic characteristics of people, objects and events (Özdemir, 2010). Documents such as textbooks, organizational documents, annual or scientific research reports, dictionaries, postgraduate theses and published articles each of which has been reviewed by experts in the field, checked for originality, edited and organized can serve as a data source (Yıldırım & Şimşek, 2021). In the study, relevant documents (books, dictionaries and articles) containing the concepts of inertia, evolution, conservatism and revolution were examined using the descriptive analysis approach.

2.3. Data analysis

In descriptive analysis, raw data are presented in a way that readers can understand, benefit from and use (Özkan, 2022). According to Patton (2018), description forms the foundation of all qualitative research reports. The best recommendation for researchers is to read and review the data they have collected repeatedly. The more time spent reading, examining and reflecting on the data, the more patterns and categories begin to emerge for the researcher (Patton, 2018). For this reason, descriptive analysis was chosen for the analysis of the data in the current study. In the descriptive analysis method, data are brought together, organized and described in a meaningful, logical and clear manner (Yıldırım & Şimşek, 2021). Then, the findings are interpreted by making appropriate inferences.

3. Findings and Interpretation

What people learn most enduringly and in the greatest detail is their mother tongue (Rancière, 2025). However, the language that children learn and speak within the family may not include many scientific concepts such as inertia because these concepts are scientific in nature. Therefore, the language used by teachers in learning environments (Gunstone & Watts, 1985; Yıldız, 2024) may not initially seem meaningful to children, as it incorporates many scientific concepts. When explaining scientific concepts to students, teachers should not limit themselves to providing only the definition of the concept, its critical features and representative examples (Erden & Akman, 2025). It is considered beneficial for them to implement additional explanations and activities that support this formal concept teaching. The same explanations and activities carried out for teaching scientific concepts should also be repeated for their contrasting and related concepts. This strategy can enable students to structure the presented scientific concepts correctly in their minds and thus can contribute to permanent learning.

A concept pool consisting of contrasting and related concepts can be created alongside the main concept to be taught. If there are contrasting or similar concepts in the social sciences (psychology, sociology, literature, politics) that are well-known, they may be preferred for explaining the target concept because well-known and frequently encountered concepts from the social sciences are more likely to be part of everyday spoken language. The number of concepts in the pool can be determined based on criteria such as students' level of education (primary school, middle school, high school and university), the grade they attend and their academic achievement levels. From fourth grade in primary school through eighth grade, it may be considered sufficient to present only the main concept and its contrasting concept. At the high school and university levels, in addition to the main and contrasting concepts, related concepts should also be included in the pool.

In the current study, considering the definition and characteristics of the main concept to be taught (inertia), evolution can be taken as a contrasting concept to this science concept. As a concept similar to inertia, conservatism from the social sciences can be selected. Revolutionism, as a concept opposing conservatism, can be considered to form a concept pool together with the other three concepts. In the Turkish Dictionary (TDK, 2019), conservative is described as traditionalist. In other words, it refers to a person who opposes change and innovations. The concept opposite to conservatism is revolutionism. Revolution is defined as making rapid, fundamental, and qualitative change in a particular field (TDK, 2019).

The relationship between conservatism, selected as a concept similar to the main concept, and revolutionism, taken as the contrasting concept to conservatism, is very well illustrated by a statement made by the philosopher Hannah Arendt. Arendt explains this relationship with the statement, "*The most radical revolutionaries become conservatives the day after the revolution.*" (Fara, 2021). Why do revolutionaries become conservatives the day after a revolution? Because revolutionaries want the innovations brought about by the revolution to be understood and adopted. Therefore, they have to protect these innovations and defend their necessity. This situation forces even the most radical revolutionary who carried out the revolution to act conservatively.

Due to the statement initially made by Hannah Arendt, people may always find her to be justified. One might even raise the thought, "If a revolutionary becomes a conservative the day after a revolution, why is there any need to make revolutions and pay such heavy costs?" Because of the inertia inherent in all entities, revolutionaries also behave conservatively after a revolution and resist change. However, new problems usually emerge after a revolution, and over time these problems may increase. Solutions to some of these problems may be delayed. In the process of seeking solutions, different proposals and new paradigms may emerge. Consequently, change begins inevitably and necessarily. In other words, the statement on change attributed to Heraclitus, who is said to have lived in the pre-Socratic period (535–475 BCE), *"The only thing that doesn't change is change itself"* (Wikipedia, 2025), emphasizes the inevitability of change. This statement by Heraclitus supports evolution, which is selected as the concept opposite to inertia.

According to Heraclitus, the universe is a harmony formed by opposites. Everything comes into being through conflict. *Opposing elements come together and from what is irreconcilable, the most beautiful harmony arises.* All these opposites are separate aspects of a whole. In short, Heraclitus states that darkness makes light pleasant, evil makes goodness meaningful, illness makes health desirable, hunger makes satiety enjoyable and fatigue makes rest pleasant (Wikipedia, 2025). Goethe expresses this opposition present in nature through pairs such as north and south, positive and negative, attraction and repulsion (Fara, 2021). For a more concrete argument, one can examine the inherent contrast within the structure of matter. All matter is composed of atoms. Atoms consist of three components. The first are the electrons, which possess a negative electrical charge, surround the atom and determine its chemical properties. The other components consist of positively charged protons and uncharged neutrons, which are tightly bound together in the tiny nucleus located within the electron cloud (Gribbin, 2025). The region within the electron cloud where the probability of finding electrons is highest is called an orbital. Orbitals are the regions where the shadowy area representing the electron cloud is most dense (Bueche & Jerde, 2010). A fully occupied orbital can hold a maximum of two electrons. However, these electrons have opposite spins. When the electronic configurations of elements are given (Serway & Beichner, 2011), it is always indicated that the two electrons in the same orbital are placed with opposite spins (↑↓). Despite the opposition present in the smallest unit of matter, the fact that atoms maintain their stable structures is sufficient evidence for the harmony of opposites in nature.

Opposites always exist in nature and social life, and each individual generally experiences them in different ways and to varying degrees. Therefore, in concept teaching, it is beneficial to first use contrasting concepts and then related concepts as supportive elements during the process of learning the main concept. The harmony of opposites in nature may validate the claim that humans, as an integral part of nature, can achieve easier and more permanent learning through contrasts. This is because basing instructional approaches on characteristics inherent in nature can facilitate participation in the learning process, as it aligns with human nature itself. Explaining contrasting and related concepts alongside the main concept can make the true nature of the main concept more visible. This visibility can enable the main concept to be learned effectively and permanently.

4. Discussion and Conclusion

In the current study, the claim that conventional concept teaching (Erden & Akman, 2025) could be enhanced by supporting it with a concept pool is discussed. Explaining the concepts in a concept pool, which includes the main concept along with contrasting and related concepts, and providing appropriate examples can enable the main concept to be learned permanently. Moreover, explaining the main concept along with contrasting and related concepts provides students with the opportunity to learn multiple concepts simultaneously. This strategy can allow students to correctly structure scientific concepts, which may not exist in their mother tongue but are included in the concept pool, in their minds by relating them to contrasting or related social concepts they have previously encountered. This claim is supported by the idea that newly learned information is structured by relating it to prior knowledge or built upon it (Ausubel, 1968; Özmen, 2004).

The examples used to explain a concept in the learning environment can sometimes convey a completely different meaning to students, leading to outcomes that differ from the intended result (Anderson, 1986; Berg & Brouwer, 1991). Presenting a concept along with its contrasting and related concepts and their representative examples can prevent the formation of misconceptions about that concept because the concept pool strategy allows for an in-depth explanation of the main concept. This in-depth concept teaching, supported by appropriate examples, can clarify what the main concept is and what it is not, thereby leaving little room for misconceptions to form. According to some studies (Gunstone & Watts, 1985; Newman & Holzman, 2014; Yıldız, 2022), one of the reasons for the occurrence of misconceptions in the field of science is the difference between the language used in learning environments and the language spoken by students. The concept pool strategy can prevent language-based misconceptions in the field of science (Newman & Holzman, 2014) because providing explanations for the contrasting and related concepts in the pool, along with their most representative examples, can make the main concept more visible.

It is also argued that science teachers are generally largely unaware of students' ideas and are not sensitive to the views students bring to science lessons (Osborne et al., 1983). The concept pool strategy can lead students to question their non-scientific views about science concepts and begin to feel dissatisfaction with them, even without the teacher's direct intervention. Questioning their own misconceptions and feeling dissatisfaction with them is an essential starting point for conceptual change (Posner et al., 1982). Establishing this starting point is considered beneficial, as it can accelerate the conceptual change process.

5. Recommendations

"Conceptual change texts" that include the main concept along with contrasting and related concepts in the concept pool can be prepared. These texts can be used to address misconceptions identified or suspected to be related to the main concept. Including contrasting and related concepts alongside the main concept can make conceptual change texts rich in content. This rich content can facilitate accurate and clear connections between concepts. This feature can make these specialized texts more effective for conceptual change.

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