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# THE SCIENTIFIC CONCEPTUAL CHANGES BASED ON KUHN'S PARADIGM

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## ABSTRACT

*The purpose of this research is to explore the background of the birth of Kuhn's paradigm theory, which had a tremendous influence on science education, and the characteristics of its structure, and to explore whether the conceptual change of individuals influenced by Kuhn for science education is well-suited to the history of science and the conditions for conceptual change. The most popular model of conceptual change was proposed by Posner's colleagues, which adopted the perspectives of philosophers of science such as Kuhn, Lakatos, and Toulmin, and assumed that the individual student change model assumes that the change that occurs in individual learning is similar to the nature of scientific paradigm change proposed by philosophers of science. As a result, it can be seen that the history of science also changes according to the conditions of individual students' conceptual change.*

**KEYWORDS:** Historicism, Social Consensus, Metaphysical Beliefs, And Conceptual Change Models.

## 1. INTRODUCTION

Thomas Samuel Kuhn (1922–1996) made significant contributions to the history of scientific thought. His magnum opus, “The Structure of Scientific Revolutions,” is one of the most widely read books in the humanities and social sciences. His ideas about the nature of science have been interpreted and applied to research in various ways by numerous scholars from psychology to education. Therefore, exploring Kuhn’s history of scientific thought in science education is extremely important.

Kuhn was a historian who studied in the history of science. He said that philosophers can also clarify their understanding of science by introducing scientific history. He criticized logical positivists with traditional scientific views for inaccurately and naively describing scientific enterprise because they did not pay sufficient attention to scientific history. As shown in the title of his book, Kuhn was interested in the Scientific Revolution, a time of considerable upheaval when existing scientific ideologies were essentially replaced by new ones. Some examples are Copernicus’s revolution in astronomy, Einstein’s revolution in physics, and Darwin’s revolution in biology. Each of these revolutions fundamentally changed the scientific worldview. A completely different set of ideas has been overturned from an existing set of ideas (Okasha, 2016).

It is first necessary to examine Kuhn’s theory of scientific revolution (paradigm theory) briefly from the structure of Kuhn’s paradigm and paradigm change. Further, regarding a revolutionary conceptual change, this study will apply the conceptual change model of Posner et al. (1982), which is the most popular model in science education (Oh, 2011, 2012), and Kuhn’s paradigm sturucture to the formation process of scientific theory to understand the changes in scientific theory as insightfully as possible.

If a change occurs between two incommensurable paradigms, it can only be a revolution. And disputes between paradigms cannot be resolved by normal scientific standards. This is because normal science presents the problem area, approach, and standard of solution, but the debate between paradigms is a debate that takes place while these parts are inconsistent (Chen, 2023, pp. 43-44). A multidimensional framework for considering conceptual change events in the classroom and attempts to synthesize various perspectives of contemporary conceptual change research by proposing that changes in students' knowledge structures be viewed from epistemological, ontological, and social/affective perspectives based on Kuhn's Scientific Revolution (Tyson , et al, 1997, p. 387).

Therefore, in this study, we explore the scientific worldview of scientific theories by dividing Kuhn's concept of incommensurability into three types as follows.

First, a narrow sense of the world, starting from the perspective of ontology (metaphysical beliefs) that underlies all Kuhn's paradigms.

Second, what are the choices and methodologies of the epistemological contributions that justify the proposed scientific knowledge from the perspective of this ontology, and how do we support such knowledge? (Ladyman, 2002, p.5).

Third, We explore Kuhn's influence on individual conceptual changes in science for science education and whether they fit well with the conditions for conceptual change and the history of science.

## 2. CRITERIA FOR A GOOD THEORY AS THEORETICAL BACKGROUNDS

It can be said that value is bound to be involved in the data obtained from human activities. This is because scientific theories and data are produced from scientific activities. We distinguish between the two kinds of values in the context of science (Crespo, 2019). As a cognitive value, it is a value commonly used in the process of determining the most plausible theories and laws about the world. These values are used in the process of obtaining scientific knowledge, and it is mandatory for scientists. It can be said to be a value that is not time and place dependent. However, the value involved when evaluating that it is not desirable for a woman to have an abortion is socially and ethically desirable if it does so, regardless of the process shaping scientific knowledge. Therefore, these values are referred to as non-cognitive values.

### *2.1. Epistemic values as aesthetic values that influence scientific activities*

Reiss and Sprenger (2014) hold that value can affect science in the following four cases: ⅰ) selection of scientific research problems; ⅱ) collection of information; ⅲ) approval of appropriate answers or scientific hypotheses to evidence-based problems; dissemination, application, and evaluation of scientific research results.

For ii, it is universally accepted that the choice of research problems is often influenced by individual scientists’ interests, funding groups, and society as a whole. These effects can make science shallower and slow and delay long-term development, but they also have advantages. Scientists can focus on providing solutions to intellectual problems that society considers urgent to improve people's lives. For the dissemination, application, and evaluation through iii, scientific research results appear to be influenced by the personal values of journal editors and end users, and it can be said that few people can object to them (Elliott, 2017).

Most philosophers of science believe that the role of value in science takes place in ii and iii and that there is a topic worthy of debate regarding the collection of evidence and the acceptance of scientific theories. The real debate on this issue concerns whether the "core" of scientific reasoning (the collection of evidence and the evaluation and acceptance of scientific theories) is value-neutral.

A clear but ultimately compelling critique of the value-neutral ideal causes "non-deciding of theory by evidence." It is frequently seen in history of science; it does not select the only theoretical explanation for that area as existing evidence in some areas. The "decisive experiment" indicates that there is an error in the entire hypothesis network without refuting a particularly scientific argument (Duhem 1906 /1954]). Thus, we often cannot determine the choice of competing theoretical explanations with existing evidence.

In this sense, philosophers of science tend to regard value-laden as a positive attribute. Cognitive (or perceptive) values such as predictive accuracy, scope, unity, explanatory power, simplicity, and consistency with other accepted theories represent good scientific theories and standard arguments for preferring one theory over another. Kuhn (1977) states that cognitive value is defined as a theoretical evaluation standard that characterizes a common scientific obligation-a scientific approach as a whole.

Occasionally, epistemic values are considered a subset of cognitive values and regarded as having the same value as empirical validity and an internal consistency that directly supports the integrity of scientific theory (Laudan, 2004). Subsequently, values such as scope and explanatory power are calculated as cognitive values representing scientific needs but without appropriate cognitive implications. Not all philosophers of science agree, nevertheless, this study decided to adopt a broader reading of "cognitive" that complements the fact that truth is not the sole goal of scientific inquiry but provides a causal mechanism, finds natural laws, and creates comprehension. In this sense, scope or explanatory power contributes to the achievement of our cognitive goals.

Kuhn's first paradigm theory (Kuhn, 1963) was criticized as relativism because the theoretical selection criteria were not clear. Concerning what characterizes good theories, Kuhn, a scientist and philosopher of science, choose five of the most common answers and ensured objectivity (Kuhn, 1977).

First, a theory must be accurate within its domain. Essentially, it must be proved that the results that can be derived from any theory are consistent with existing experiments and observations. Second, a theory must be internally consistent, relevant, and consistent with currently accepted theories. Third, theories should be broad in scope. In particular, a theory should be extended beyond individual observations, laws, or sub-theories designed to explain it in the first place. Fourth, as it relates to the third characteristic, a theory should be simple in the sense that it brings order to phenomena that are isolated and confusing without it. Fifth, a theory should produce numerous novel research results. In my view, it refers to the "fertility" of the study, which produces subsequent studies.

When interpreted as a prescriptive criterion for theoretical selection, these values Kuhn presented could escape the criticism of relativism that was directed at the first edition (Kuhn, 1962; Hess, 1997). In this section, Kuhn's proposed cognitive value is considered by categorizing it into external values that expand knowledge, values that add aesthetic meaning to the understanding of knowledge, and internal values that show the internal solidity of scientific theory.

Accuracy, scope, and fruitfulness are all standard frameworks for evaluating the cognitive value of a theory as external values of theories that expand knowledge (Kuhn, 1977).

Looking at the cognitive values presented by Kuhn in terms of content, it is confirmed that they are closely related to explanatory power and empirical accuracy. Accuracy corresponding to internal value is also a prerequisite for the objective of explanatory power and empirical suitability (Jo, 2017). Among the cognitive values, it indicates the importance of the accuracy of experience.

Special relativity, for example, includes Galileo's principle of relativity but is more accurate. It gives results similar to Galileo's principle of relativity for slower movement than the speed of light. However, it can more accurately explain faster movements similar to the speed of light that Galileo's principle of relativity cannot explain.

Here, the expansion, productivity, and accuracy of the theoretical scope are closely connected as a group. In terms of accuracy, it has the same meaning as the expansion of scope or productivity as a logical result derived from future predictions.

As the internal value of the theory, it adds aesthetic meaning according to the understanding of knowledge and has a reflective relationship with nature. It is a characteristic that demonstrates the beauty of the theory through the internal solidity and characteristics of a scientific theory.

Simplicity and consistency are also closely related to each other. The criterion for simplicity is closely related to consistency—it must be judged in the context of other theories (Hess, 1997). If a faster-than-light signal is discovered, it will necessitate fundamental modifications in mechanics, thermodynamics, atomic physics, and cosmology. The argument for the speed of light is deeply and strictly embedded in the structure of the theoretical description of nature. This leads to inevitable consequences (Kosso, 2007). Inevitability is a type of coherence. We can understand the inevitability as a non-empirical aspect derived from the connection to a theoretical system. More observations are about gaining more knowledge but not more understanding (Kosso, 2007).

For example, there is a significant difference between Bode's law and the speed of the conctancy of the speed of light. With the constancy of the speed of light, many theories consequently follow, such as the combination of time and space, which states that as mass increases, mass energy experiences an equivalent increase. Nevertheless, Bode's law has little connection. It demonstrates the importance of consistency between theories among cognitive values and indicates the internal and aesthetic characteristics of theories through a deeper understanding of theories. In general, symmetry refers to something in proper harmony and balance. It refers to the shape in which several parts coincide and conform with each other to make a whole. Beauty is closely related to symmetry. Therefore, symmetry is a characteristic that shows the beauty of scientific theory by understanding it as an internal characteristic of theory among cognitive values.

Simplicity can be determined by the number and type of premises of the accepted theory. Newtonian mechanics, for example, is described on the premise of time and space as a metaphysical absolute divine attribute, but general relativity presupposes observational facts rather than such divine attributes. Therefore, general relativity has relatively simple premises. Space-time and space exist independently of Newton's Law and the universal law of gravity, which are the interactions of matter in space and absolute time that constitute Newtonian mechanics. In essence, the inevitability is weak.

However, Einstein's general theory of relativity has a strong inevitability because combination of matter and energy inevitably leads to the bending of the gravitational field, time, and space. After all, general relativity theory has extremely strong consistency, which is a binding force between theories.

Logical positivism states that scientific theories are cumulative and that the order of use of these scientific values-cognitive values-shows algorithms. If there is a choice of theory, the weight of the empirical accuracy of a scientific theory is prioritized first, followed by simplicity.

In the revolutionary process, the simplicity of the theory is initially weighted, but as the justification of the theory progresses, the consistency is weighted. This is because the weight of the accuracy of the theory is important, but in the revolution process, it is difficult to propose a new theory if the accuracy is promoted from the beginning. The justification of scientific theory does not proceed with certain algorithms claimed by logical positivism.

We study nature objectively in part. However, the evaluation of the results obtained from these scientific activities cannot be purely objective. The zeitgeist of each period plays a significant role in the non-cognitive value of research evaluation. Science is bound to have a subjective element. This is because humans create science (Fischer, 2000), and one can understand the limitations of science only when one deeply understands these simple facts.

A scientist can suggest that there is ample work to be done in science by merely answering questions about facts, not values. Although the question of facts is one of generality, there is a limit to such a question.

Science can accurately determine the nature of a virus, such as a single COVID-19 virus. Science widely estimates how a particular virus is related to a particular disease. However, science does not say anything about how the emergence of these new viruses will affect communal human life. In the past, scientists answered when we asked questions. Today, we ask questions about ourselves. The answer to this question can only be found after we agree on the value of this question.

In the souls of scientists, metaphysical ideas influence the formation of scientific theories. Ptolemy, Copernicus, and Galileo have something in common-they all assume circular motion. Insistent obsession with isometric movements of ancient Greeks such as Pythagoras, Plato, and Aristotle was the basis of the traditional part of Copernicus's heliocentric system. Furthermore, the emphasis on the exact observations of Tycho Brahe, along with Pythagoras' belief in mathematical harmony, inspired Kepler's study. Another theme in this narrative is the social and cultural influence on thought. As humanistic activities and new ideas emerged during the Renaissance, it became a time to reevaluate old ideas in general (Derry, 1999).

Period-specific socio-cultural values and previous scientific theories play a crucial role in the process of theory selection and formation by scientists. The aesthetic values of Western thought also play a significant role.

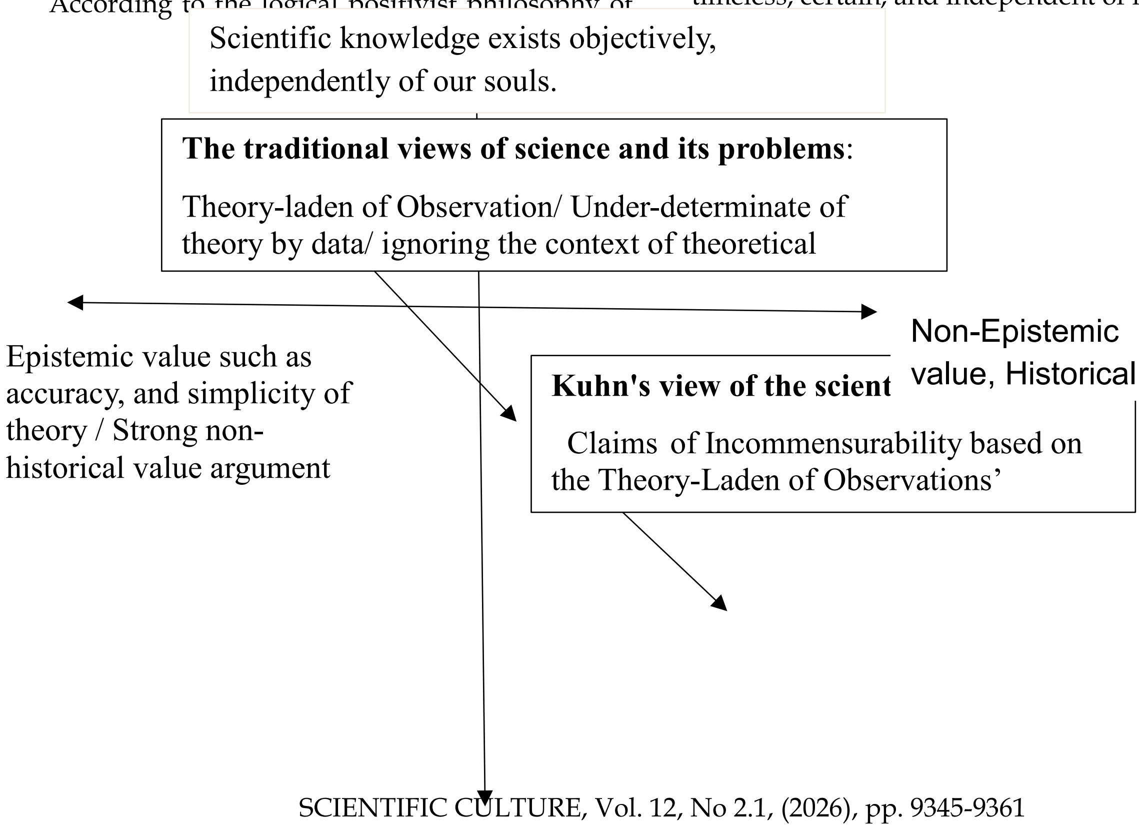
## 3. TRADITIONAL SCIENTIFIC PERSPECTIVES AND CHARACTERISTICS AND INFLUENCES OF KUHN'S THEORY OF SCIENTIFIC REVOLUTION

In the traditional and standard view of science, the reality of nature exists as the theory and law of science. The methodology to support and confirm it is that they are discovered and selected from the data by a reasonable method of inductive reasoning.

However, Kuhn propesed a new philosophy of science that does not follow such "logical and empirical rationality" but "historical rationality" that emphasizes the value of social culture at the time. As a representation of the natural world, it has been argued as an epistemological critique of the standard view of science or enlightened rationalism, which has dominated Western philosophy since the 17th century (Giere, 1993).

According to the logical positivist philosophy of science-one of the traditional and standard views of science-arguments between competing scientific theories could be resolved in a perfectly objective manner. It was assumed that the dispute over the choice between competing theories could be resolved by "neutral" observations recognized by all parties. Their belief that science is rational and objective was firm because, without a clear difference between theory and observed facts, the rationality and objectivity of science would be at stake. In particular, they argue that there is a kind of algorithm in the theory selection process. They argued that the accuracy and inclusiveness of the theory are prioritized first, followed by a linear algorithm called the simplicity of the theory.

The implicit premise of scientific law or theory—a propositional knowledge found in nature—is based on the metaphysical belief that it exists objectively in the external world. Regardless of external historical socio-cultural values, it is argued that such new rules (laws or theories) are discovered using a methodology called induction, starting with rational, objective data. Furthermore, the richer the data, the more it nears the truth, and scientific theory develops cumulatively. This view holds that science exists first, and human society discovers it. A traditional view considers science as an abstract knowledge system that exists independently of human culture, and a constructivist view proclaims the involvement of human culture. The former emphasizes the structure, consistency, and logic of scientific knowledge. Such a scientific theory is an axiomatic system related to the empirical world as a response. Science is considered timeless, certain, and independent of human culture



Instrumentalist and anti-

**Social constructivist:**

Kuhn's legacy Strong weight on external factors such as social consensus

***Figure 1. Scientific, Philosophical, and volution Theory.***

Therefore, as induction is an important research method, it is referred to as inductivism. As science uses evidence called data unlike other disciplines, it is referred to as scientism. Such scientific theories and laws exist objectively, and it is referred to as objectivism. The popular belief that science is a cure for all ills can be viewed as a form of scientism (Preston, 2008).

Traditional philosophy of science refers to a philosophy of science that inherits tasks and methods from logical positivism and critical rationalism. Their philosophy continues the modernist tradition of modern science-it presents a theory that justifies the universal logic and method of science based on the tradition of Western philosophy. Philosophers who continue this tradition include Descartes, Kant, and logical positivists such as Hempel and Carnap in the 20th century. Furthermore, there is also critical rationalism centered on Popper, and scientists such as Newton and Einstein belong to this tradition. What needs to be examined is what led Kuhn to believe that there was a serious problem with traditional science, especially the arguments of the logical positivists, which he accepted until he studied the history of science.

First, Kuhn emphasizes the community and social nature (historical value rather than reason) that scientific work inherently constitutes. This shows that natural science also has the same social character as the scientific community.

He focuses not only on the metaphysical role, but above all on the role of the historian. In other words, it can be seen that he introduced Kantianism in that he emphasized the conceptual framework and Darwin's theory of evolution in that he was a historicist and naturalist (Sarrock, and Read, 2002).

Second, a scientific theory, combined with Hanson's theory-ladenness of observations (Hanson, 1958) and Quine's theory of underdetermination, cannot be sufficiently determined by evidence or data.

When we collect data by observing a phenomenon with the theory-ladenness of observation (theory-dependence), it is difficult to collect completely objective data because we examine certain phenomena with our theories and preconceptions.

It is difficult to choose or deny a theory with any decisive experiment predicted by the indetermination of theory. For example, if Venus's phase change appears to be more than a full moon shape, Copernicus's heliocentric theory is correct, and Ptolemy's geocentric theory is wrong, but Tycho's geocentric theory can predict the phase change of Venus.

Therefore, the choice of a scientific theory is determined by external social factors surrounding science, which are non-epistemological. Social interests combined with epistemological factors completely determine scientific theory.

If a replacement occurs between the two incommensurable paradigms that Kuhn advocated, it can only be a revolution. And disputes between paradigms cannot be resolved by normal scientific standards. Normal science presents the problem area, approach, and standard of solution, but the debate between paradigms is a debate that takes place while these aspects are inconsistent.

It has been significantly influenced by many scientific history case studies. Some science historians believed that Darwin's theory of evolution could be developed in the Victorian era of England because political economics was in full swing, claiming that social economic development was achieved through intrinsic economic factors and close interactions with the surrounding political environment. He focuses not only on the metaphysical role, but above all on the role of the historian. It can be seen that he introduced the evolution theory of Kant and Darwin (Sharrock, and Read, 2002).

This idea that competing paradigms are incommensurable is supported by the theory-ladenness of observations. If it is true that all observations are contaminated by background theories then the merits of each paradigm cannot be compared (Ladyman, 2002, pp.116-118). Above all, when the problem of value is involved, such as "Which problem is an important problem worth solving?", it cannot be solved through logic alone. We have no choice but to rely on existing things outside the paradigm. Finally, it can be said that the choice of values varies relatively depending on the culture to which they belong (Chalmers, 1999).

First, the differences and incommensurability between paradigms are the level of ontology(metaphysical beliefs) and so on are global and systematic. the point about Gestalt switches is that they are holistic, this is called ontology incommensurability. The main cause of ontological incommensurability is likely to be the theory-laden nature of observation. This theory-loadedness can be said to be connected to contemporary and historical values.

Second, theories within different paradigms are in incommensurable, in the sense that the terms and concepts of scientific theories in different paradigms are not mutually intertranslatable, this is called meaning incommensurability. Therefore, there are some people who argue not the scientific knowledge is relative, but in the end, that reality itself is socially constructed. It can be said to be an incommensurability of social and cultural values.

Third, it is about the incommensurability of methodologies for the problems to be solved between competing paradigms. In my opinion, this methodological perspective can also be said to start from the first ontological perspective. Differences also arise in the methodology of justifying scientific theories proposed from different ontological perspectives. This is a branch of epistemology: What is the scientific method? How does the evidence support a theory? These are questions about the question:

Meanwhile, research that analyzed the theoretical systematization of electrical phenomena discovered in the 19th century shows that in late 19th century England, empirical and experimental traditions led to the development of electromagnetism. However, in Germany and France, where mathematical and theoretical traditions were strong, a completely different system of electrical dynamics has been developed accordingly. Although differences in institutional and cultural environments deal with the same phenomenon, fundamentally different scientific theories emerge. Another science historian found why non-deterministic quantum mechanics, which provided only stochastic explanations and predictions, emerged in Weimar, particularly after World War I. The German people had uncertainty about the future after the defeat in the war, and its physicists were hostile to the deterministic physics of British Newtonian mechanics.

The main argument of the theory of the scientific revolution (paradigm theory) is that the constructed laws and theories are not facts that exist externally, regardless of our existence, but an explanatory system or explanatory model. It also assumes that such an explanatory system is revolutionized and transformed by a new explanatory system rather than developing cumulatively.

It is argued that scientific theories are selected according to the social consensus of the group of scientists at the time and according to socio-cultural values based on external factors such as history. Subsequently, new data are collected to justify the laws and theories.

It is said that the research method is composed of theory-ladenness according to the subjectivity of the scientist's observation rather than scientific activities according to a separate set of rules. Therefore, social consensus (Preston, 2008) is a criterion for selecting a theory. Further, it is referred to as constructivism by emphasizing relativism and subjectivity according to a scientist's creativity. In other respects, it is called intersubjectivity. Thus, it is conducted in a way that most scientists can agree with each other.

These are postmodern scientists who have naturalistic tendencies based on Kuhn's historical philosophy of science. However, the notable aspect is not that the changes in science are unreasonable but that the commonly used concept of rationality is extremely demanding. He argues that paradigm shift is not unreasonable but that a weaker concept of practical rationality is necessary to understand paradigm shift (Okasha, 2016).

As shown in Figure 1, an important influence of Kuhn's work was that it attracted attention to the social context of science that the traditional philosophy of science had ignored. In particular, the movement known as the Strong Program in scientific sociology emerged in the UK in the 1970s and 1980s, largely due to Kuhn. Most of the scientists' beliefs were considered socially determined (Okasha, 2016). The Strong Program borrowed several topics from Kuhn, including the view that it is essentially a social activity based on the impossibility of pledges and the data's theory-ladenness. This view is more radical than that of Kuhn.

While Kuhn's argument has been tried to undermine the charge that it is irrational, Paul Feyerabend, most famously, proudly embraced it in Against Method (Feyerabend, 1975). And sociologists of science, especially supporters of the Edinburgh "strong program," have taken their entire "strong program" as a premise for its validity. As Barry Barnes put it in Interests and the Growth of Knowledge, "Recent historical research, especially that of T.S. Kuhn (1970), has effectively undermined the belief that science is rational. They show that fundamental theoretical shifts in science are not simply rational responses..." (Barnes, 1977, p. 22).

### *3.1. Structure Of Kuhn's Paradigm*

As an appropriate explanation for the traditional scientific views of induction and critical rationalism, one of Kuhn's characteristics of science was to present the nature of science consistent with the actual history of science based on scientific history (Chalmers, 1999). Moreover, one of the basic beliefs is that knowledge of science is not the accumulated growth of scientific knowledge, which brings together more and different kinds of observations and creates new concepts. Nor is it that old concepts become renewed, and the new laws that exist between them are constantly growing through the process of discovering them. Instead, the old paradigm is replaced by a completely different new paradigm.

Such a paradigm examines how the structure is constructed and what changes are made in the history of science.

Understanding the structure of the paradigm and the theories of science through it.

It is characterized by a unique paradigm that requires scientific theory to be viewed as a structure through the study of scientific history. Kuhn proposed four elements as a discretionary matrix. It was categorized into symbolic generalization, model, value, and legends (Kuhn, 1970). The paradigm comprises two main components. The first is a set of fundamental theoretical assumptions, which is accepted by all members of the community and the scientist. The second is "exemplar," a set of specific scientific problems solved by such theoretical assumptions. We largely categorized paradigms into two ways mainly dealt with in education (Okasha, 2016). We categorized the former as a <specialized field-based> that explains the background belief system in the scientific research process and the latter as <exemplary cases> that often appear in textbooks as practice problems or classical problems well known in certain research fields and success stories corresponding to standard solutions. These exemplary cases increase the overall size of the paradigm in the process of problem-solving—a routine process of science—and elaborate and produce success stories.

The specialized field-based is a process of knowing. The value argument systems (e.g., consistency, simplicity, accuracy, and usefulness) that select and judge theories and laws could be the criteria for epistemologically justifying them. Such justification value claims can culminate, and the metaphysical belief system has rights based on the entire paradigm on the premise of the implicit assumption of the entire paradigm as well as theories and laws.

The positivists focus on justifications, and Popper's critical rationalism deals with changes in scientific theory that came after Aristotle to modern theories of relativity. However, this perspective was formed only in terms of phenomenological scientific theory, ignoring the metaphysical background. Nevertheless, the metaphysical theories of Newton's action-at-a-distance causality and his deterministic causality were the dominant forces behind his theory. Therefore, this study seeks to examine the theoretical changes that begin with these metaphysical beliefs(Oh, 2022).

In Figure 2, to resolve dissatisfaction with the existing paradigm caused by new socio-cultural factors, theories and laws were proposed as implicit premises of a new metaphysical belief system. If the theories and laws are justified and chosen by the value system resulting from the metaphysical belief system at the time, such theoretical laws are approved by a group of scientists and accepted as a new paradigm (completion of the scientific revolution). However, due to the emergence of new socio-cultural factors that show the importance of anomalies rather than the increase in the number of anomalies in the existing paradigm, a theory based on a new metaphysical belief is proposed in the crisis of the existing paradigm. There is a socio-cultural factor in the exclusion of what was accepted without resistance in the past (Daston, 2018).

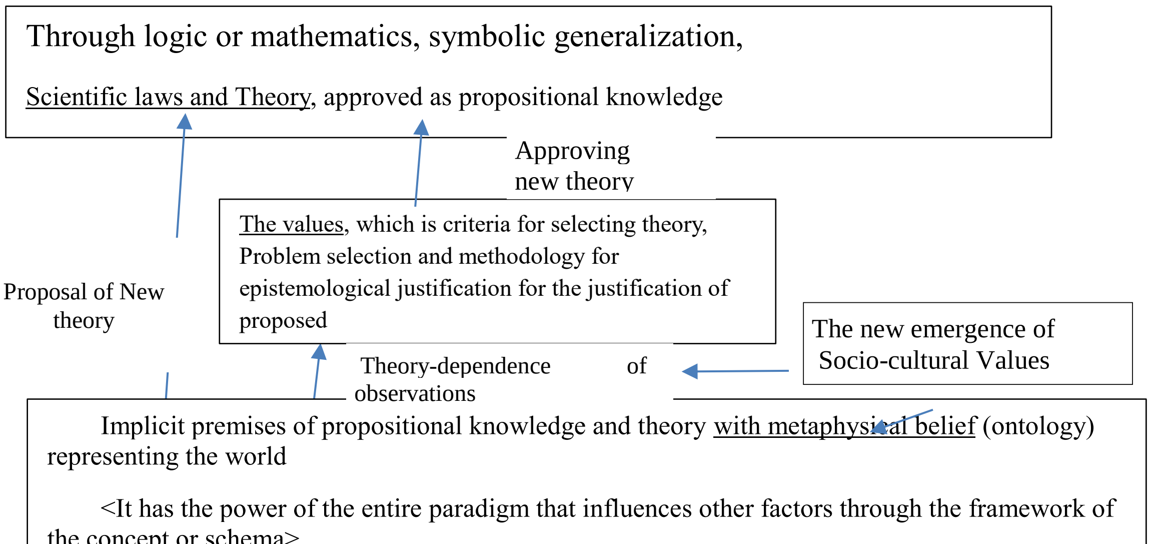


*Figure 2. Relationship between the central core of the paradigm.*

## 4. PARADIGM CHANGE IN THE HISTORY OF SCIENCE FROM AN EDUCATIONAL PSYCHOLOGY PERSPECTIVE

Researchers studying students' concepts and conceptual change often use the historical analogy of science. This analogy is usually used when students' concepts are similar to scientific concepts in the history of science. This analogy assumes that students' alternative concepts are partly similar to the ideas that great scientists of the past had before, that is, the process of students' conceptual change is similar to the process of developing scientific theories (Oh, 2011).

The most popular model of conceptual change was proposed by Posner's colleagues (1982), which adopted the perspective of philosophers of science such as Kuhn, Lakatos, and Toulmin, and assumed that the individual student's change model assumes that the changes that occur in individual learning are similar to the nature of scientific paradigm changes proposed by philosophers of science (Tyson, et al., 1997).

Educational psychologist Posner and his colleagues (1982), who had a tremendous impact on science education, state that conceptual change arises from the dissatisfaction with existing concepts by accepting Kuhn's theory of scientific revolution. They argued that conceptual change should be made only when minimal intelligence of new concepts, the plausibility of new concepts, and fruitfulness are shown. Therefore, this study applies the process of conceptual change to Kuhn's scientific revolution process of scientific theory. Their model assumes that changes in individual learning are similar to the nature of the scientific paradigm shift proposed by Kuhn, a philosopher of science (Tyson et al. 1997: Oh, 2011). Within this multidimensional framework, conceptual change can be viewed through three lenses—an ontological lens, an epistemological lens, or a social/affective lens.

Figure 2 shows the emergence of new socio-cultural elements to resolve dissatisfaction with existing theories (dissatisfaction with existing theories). Theories and laws are proposed as the implicit premise of a new metaphysical belief system at the time (the minimum intelligibility of the new theory). If it is justified and selected by the value system resulting from the metaphysical belief system at the time (the plausibility and usefulness of the new theory), such theoretical laws are accepted by the society of scientists (conceptual change).

Therefore, this study applies the conceptual change process to Kuhn's scientific revolution process in scientific theory. Their model adopts the perspectives of philosophers of science, such as Kuhn, Lakatos, and Toulmin, and assumes that the change occurring in individual student learning is similar to the nature of change in the scientific paradigm proposed by Kuhn, a philosopher of science. (Tyson, et al. 1997: Oh, 2011; Oh, 2012). The increase in students' conceptual understanding is said to increase the status of the concept (Hewson, & Hewson, 1992). Students' Conceptual change is used to mean that the status of a proposed concept increases, and what is important is that students' conceptual change, or concept status, gradually increases during the process of justifying the concept.

Hewson (1985) describes epistemological commitments as "the standards which a person holds which he or she uses to judge knowledge" (p. 164). His conclusion is particularly relevant for a multidimensional approach to conceptual change.

I have tried to make it clear that such commitments (epistemological) are not sufficient to explain student learning in science. To do that, it is certainly necessary to consider, at least, the specific content of the knowledge that students hold, the way in which that knowledge is structured, where and how they obtained it, and of course how each piece of knowledge is related to other knowledge that they possess. The point about each of these aspects is that they are all important in their own right, and need to be studied. But in doing so, it is remarkably easy to lose sight of epistemological commitments, to take them for granted, to assume that we need never worry about them. As far as instruction is concerned, I believe this is particularly true. Since I also believe that they play an essential role in learning, I hope that by making this role explicit, I shall encourage others, besides myself, to investigate ways of including them in our teaching. (p. 171)

Above all, the change in students' concepts is very similar to the process of justifying scientific theories in the history of science (Oh, 2011, Oh, 2012). Ultimately, we must explore and show the justification process of these theories in the history of science and natural science.

### 4.1. Ideal Physical Paradigm of Plato in Ancient Greece

Plato suggested that the best way to understand the material world is through logical and mathematical analysis. In the field of science, he left his greatest mark on astronomy. In Plato's view, the celestial bodies of stars and planets are in the sky, making them the least polluted in the material world. The sky must be complete. Above all, it must remain unchanged. This is because it is assumed that if one goes through a change from a complete state, it changes for the worse (Henry, 2012, p. 18).

Therefore, to preserve the complete and unchanging properties of the celestial body, Plato thought celestial bodies were perfect spheres that rotated in concentric circles. Plato's solution was to help astronomers, who were geometers at the time, to explain and rescue the confusing motion that appeared in the celestial body that Plato did not expect with certain geometric principles.

Plato did not limit his ideas about the material world to astronomy and cosmology. He saw that despite the variability of the material world, it could be understood from a geometric perspective. He said there are four of the five regular polyhedrons of the atomic version of Empedocles' four-element theory. Plato tried to interpret the material reality geometrically, like the motion of a celestial body.

First, as a socio-cultural factor that requires new morality, it is to resolve the relativity problem of sophists' knowledge (dissatisfaction with existing knowledge) and transcendent and independent forms that do not change. Its structure and discerning function are mathematical structures. Based on the premise that it exists as a mathematical static world with the idea of good (the whole paradigm of power in a metaphysical belief system), the mathematical structure of the universe is proposed as an immutable law (the proposed concept). <Proposing a new concept on the premise of a metaphysical belief and a minimally intelligible understanding of the concept>

Second, in order to protect the complete and unchanging properties of the celestial body, Plato thought that the celestial body was a perfect sphere in which it rotates in a concentric circle. Plato's solution was to explain to the astronomers, who were geometers at that time, the confusing motion of the celestial body that they did not expect with some geometric principles (by claiming the value of consistency and simplicity). (The concept is plausible with the justification of the proposed concept, weighted to the coherence theory of truth).

Third, he saw that despite the variability of the material world, it can be understood from a geometric perspective. The atomic version of Empedocles' four-element theory was expected to be four of the five regular polyhedrons. Plato tried to interpret the material reality geometrically, like the motion of a celestial body. However, many parts of a real object differ from reality.

Therefore, qualitative predictions are as expected, but practical predictions are not adequately made.

(As empirical truth responsiveness is difficult to establish, it is difficult to become a modern scientific concept due to the low weight of the theory's accuracy. The difficulty with the application of the theory—a problem with fruitfulness).

Fourth, Plato tried to prove that one can reach the highest limits of truth, which is good, and the important meanings of physics only through reason (especially logic and geometry) based on, that time, social-cultural value, Furthermore, he tried to prove that he could reach the truth through mathematics.

### 4.2. Paradigm of Aristotle's Natural Philosophy in Ancient Greece

The cosmology of ancient Greece can be categorized into astronomy, which discusses the motion of celestial bodies, and natural science, which discusses the motion of the earth. Aristotle defined natural science as the study of "change," and its core was kinetic theory. The movement here is a broad concept that includes changes in quantity (generation and extinction), quality, and location.

First, to solve sophists' problem of relativity (dissatisfaction with existing knowledge), Aristotle assumed the emergence of socio-cultural elements that knowledge (truth) does not change. He assumed an implicit metaphysical belief of the time that exists as a static universe (an ontological model) of biological organisms with their unique positions according to the hierarchy of purpose. Moreover, to explain the constantly changing phenomena on the ground in a fixed, round universe over time, he proposed a theory of motion that transitions and changes from potential to reality (a new concept proposal based on metaphysical beliefs, minimal intelligibility of concepts).

Second, for example, the qualitative explanation that fruits, which are composed of moisture and flesh, fall into the land comprising water and soil components, which is their original location, is well matched with the suggestion that it is a transition from potential to reality (the value claim of consistency). (A logical and rational justification that puts weight on the coherence theory of truth-the concept is plausible).

The major concepts or principles used in Aristotle's physics are closely intertwined with each other, so it is not possible to understand each concept independently from other concepts or principles (Kuhn, 1987, pp. 15-20).

Third, if the mass of the fruit is twice as large, it is expected that the purpose of exercising its unique position in the huge hierarchical system will be twice as large. However, the difference is not considerably significant.

Therefore, qualitative and qualitative predictions are as expected, but quantitative predictions are not made adequately. (As it is difficult to establish the empirical truth response theory-because it is weighted low on the accuracy of the theory-it is difficult to have a status as a modern scientific concept-Problem with Fruitlessness).

Fourth, in ancient Greek philosophy, since good is considered right rather than nice, maintaining one's position is right for all, and it is the highest value as a moral good. (The holistic zeitgeist of the organic worldview based on, that time, social- cultural value

### 4.3. <Metaphysical Idealism>

According to the idealistic perspective, time is only a concept; therefore, it is connected only to (human) consciousness (Zwart, 1976). From our perspective, it is a finite and fixed space-time that must be rooted in an infinite God or human thought outside the universe distinct from us. A finite but fixed time and space are idealism if the basis is metaphysical and rational human thought. Aristotle's metaphysical and teleological explanation remains in metaphysical idealism.

In physics education, the process of change in physical ideas from Aristotle to Newton is considered important. This is because if the ideas of ancient people including Aristotle are extremely simplified, [89] they are closer to physical understanding that can be easily intuitively grasped without background knowledge. It is possible to apply the 2,000-year process of accepting these ideas and then correcting them in secondary physics education. Therefore, the following Newtonian paradigm is explored.

### 4.4. Newtonian Paradigm

First, we discuss the scientific worldview of Newtonian mechanics. In contrast to the qualitatively limited world in which Aristotle's celestial and terrestrial laws of physics differ (dissatisfaction with existing theory), it is a world represented by the unchanging knowledge of the world, in accordance with the socio-cultural element of the human spirit of the Renaissance to escape the Christian personality. In the static universe, which is the nature of God, a fixed or absolute space-time, God with infinite abilities created matter (ontology). Various masses of one physical quality are inertial and considered mechanical systems (heuristic models) (the metaphysical belief representing the world). It is assumed that the universal law of gravitation between various masses is applied. (A new conceptual proposal that presupposes metaphysical beliefs, the minimum level of intelligibility of such concepts).

Second, if the sun is a voluminous point mass, the Newtonian theory is consistent with Kepler's elliptical motion and explains Copernicus' heliocentric theory to position the sun because the center of the sun is located in the center of Kepler's rotating ellipsoid. Therefore, it fits well with pre-existing theories. However, as there is no close relationship between the law of universal gravitation and Newton's law, there is a weak consistency value claim. In the process of knowing, through the internal value of theory, concept status is established as a reasonable concept according to the coherence theory of weak truth; the concept is plausible).

Third, it is also expected that if an apple with an arbitrary mass is horizontally projected at various speeds on the ground where universal gravitation is applied, the apple with a higher speed will fall further and rotate around the Earth without falling to the ground, much like the moon. Further, satellites orbit the Earth according to this principle. Additionally, if expanded into the solar system, Halley's Comet, which rotates around the sun, appeared as predicted, and many phenomena are found in the natural world as predicted (the value claim of accuracy of experience). (In the process of knowing, it is possible to gain status as a scientific concept as the weight is placed on the empirical truth response theory, which is an external value of a theory. Fruitfulness).

A statement is true when it corresponds to the facts, The terms in the statement refer to things and properties in the world. The conditions under which statements are true or false (truth-conditions) are objective, and determine the truth or falsity of those statements depending on how things stand in this world (Ladyman, 2002, p.157), Fourth, the world we can predict can create a utopian world on the ground. Owing to qualitatively different ingredients, apples were already destined to fall to the ground, and the moon was destined to continue to move in a circular motion in heaven. This kind of organic world, stated by Aristotle's teleology, has long been a mainstream idea in the West. However, Newton's causal determinism, which says that apples may fall to the ground but also become the moon by universal gravitation at different horizontal initial speeds, has become the mainstream of our scientific thought since the advent of modernity.

### 4.5. Metaphysical materialism

In Newtonian mechanics, if space-time is infinite and eternal, it does not rely on a separate God outside the universe but relies on self-fulfilling things. Furthermore, it relies on mathematics, which is believed to be perfect, and God's infinite power is stronger than the God of standard Greek

philosophies, since God is not only a first cause (like the Aristotelian God) but also the cause of nature,. That the material beings are created by God and that they have intrinsic (natural) proprieties is not a new idea introduced by Newton but by traditional Christian worldview(H. Floris Cohen, 1994). However, absolute space-time-a coordinate concept-exists first, and humans and the natural world are in space-time where God-created materials are exist.

All individual objects in nature except humans are passive objects from which the soul has been removed, and it is a quantitative and mechanical world perfectly applied by the predictable laws of science.

### 4.6. Paradigm of Einstein's Theory of Relativity

Einstein believed that Aristotle's "why" (the teleological explanation) and Newton's "how" (the causal explanation) could be combined to understand reality in different ways. Rather than starting from a supernatural God, a metaphysical being, the theory of relativity was derived from existing theories and observational facts. Furthermore, it was a form of scientific naturalism well-suited to socio-cultural factors at the time, including aesthetics - a human psychological factor. It is not the force applied, but the space-time is bent by mass and energy, and all objects move in response to the space-time bent by inertia. Einstein's field equation, which presupposes nothing transcendent, is aesthetically beautiful in its simplicity of explaining the bending of time and space by energy density based on the absolute speed of light. It is a kind of dialectical logic that combines Newton's causal explanation based on teleology.

First, we discuss the formation of the theory by the scientific worldview of general relativity. The belief that the world's knowledge should be dialectically integrated (the power to influence the entire paradigm with the metaphysical belief that we must integrate the world aesthetically), socio-cultural elements of the time that wanted to exclude the infinite capacity of Newtonian mechanics (dissatisfaction with pre-existing theories), in the dynamic universe (the ontological model), a space-time that varies with the mass of energy and matter, based on symmetry, an aesthetic value that all physical laws must also be applied in the gravitational field, the teleological explanation that the universe should be aesthetically integrated becomes the cause of the causal explanation, and the gravitational field equation, a universal law, is formalized. (New concept proposal based on metaphysical beliefs, minimal intelligibility of concepts by the internal value of theory in the process of knowing).

Einstein was arguably influenced in the development of relativity theory by positivistic leanings, but this certainly does not mean the realist should adopt positivism. There is also an apparent circularity in using metaphysical considerations to discover which is the best physics we have that then tells us what metaphysics to adopt (Ladyman, 2002, p. 257).

Einstein was a naturalist who included historical cases and psychological research, and rather than using any particular metaphysics, it can be said that Einstein used a combination of empiricist experience and rationalist metaphysics.

Second, space-time - a mass and gravitational field that constitute a mathematical field equation well established even in non-Euclidean space - is cognitively plausible because it has a close relationship with each other (strong consistency value claim, the concept is plausible).

Third, it can solve the existing problem of perihelion of Mercury. It also predicted that light bends in a strong gravitational field with a large mass. Countless other phenomena have also been predicted. Such a gravitational lens phenomenon occured as predicted, and many other phenomena are found exactly in the natural world as predicted (the value claim of accuracy of experience). (In the process of knowing, the concept is used as a scientific concept because empirical truth response theory is established, Fruitfulness).

Fourth, the aesthetic value of theory toward the simplicity and consistency of scientific theory was considerably important. The modern belief in the principle of beauty was cemented by the use of beauty in the formation of standard models and general relativity. Einstein's theory of special relativity and general relativity states that the symmetry requirement is the beauty of integration (enhancing plausibility in the process of knowledge) (Hossenfelder, 2018).

In Einstein's general theory of relativity, if space-time is finite but boundary-less, it becomes self-fulfilling, not dependent on anything, relying on mathematics in which the power of the infinite God, which is believed to be perfect, is weakened. However, time and space exist first, and space and matter are dependent on each other rather than humans, and the natural world exists in time and space where God-created materials exist. Rather than a predictable mechanical world that does not change, it is a universe created and transformed.

### 4.7. Aristotle's theory of motion

Aristotle's theory of motion states that all objects have motion in the process of actively finding their original position. In this theory of motion, consistency for epistemological justification is a value argument that one's unique position is a universal self-evident reason.

This value judgment is based on the belief that it is for the self-realization of individuals, which is teleological, and a metaphysical belief that it is an organic world of the biological souls. Like Plato, power was given to individual shapes, which are mental domains, rather than substances that are hyle.

As this teleological explanation finds the cause of phenomena and movements in the future called purposiveness, it is difficult to predict quantitatively and accurately because it is a qualitative explanation.

### 4.8. Newtonian mechanics

Newton's second law states that when an object or molecule is subjected to an external force, a change in motion occurs because of passive consequences. This is an epistemological justification value argument in which empirical accuracy is extremely important.

This empirical accuracy can achieve a utopia that aptly utilizes nature for anyone if one knows exactly how the world works.

This empirical accuracy comes from the basis of causal mechanical beliefs as a passive force because there is no biological soul other than human beings. Unlike Aristotle and Plato, Newton had an advantage in the physical realm over the mental realm of shape.

Causal explanations can be seen with predictive ability because they find causes in past empirical data. They are quantitative beings that can be applied to mathematical equations rather than qualitative ones.

Consequently, socio-cultural factors affect the crisis of the existing paradigm at the time. However, in the process of justifying the new paradigm, cognitive values are not intervened by strict algorithms. Rather, it is a loose practical rationalism that dynamically combines or affects each other. Nevertheless, it is at the center of a change in metaphysical beliefs.

In particular, looking at science from the perspective of Kuhn's paradigm, one can help us understand science more deeply. For example, it can reveal implicit metaphysical premises that are part of scientific practice but not openly discussed by scientists. Through such metaphysical premises, one can also know the value and methodology of selecting and judging such theories. In other words, Kuhn tells us why philosophical analysis is necessary in science.

### 4.9. Understanding Kuhn's Paradigm Structure and Theoretical Change in the Process of Change

This transition between paradigms is not because the new paradigm solves problems better or provides better explanatory power than the previous paradigm. This is because the new paradigm has not solved the continuing anomalies. Kuhn emphasized the social nature of the scientific community and tried to find the objectivity of scientific knowledge in the intersubjectivity of the expert group, arguing that the paradigm's selection criteria vary according to the times. What a group of scientists at a specific time believe to be important becomes the standard for paradigm selection on common criteria. According to the socio-cultural values at the time, a paradigm is selected by the social consensus of the scientific group at the time.

Ptolemy's geocentric theory, for example, states the stability of the solar system or the universe based on the perfect circular motion around a fixed earth. This is the realization of heavenly perfection and serving the purpose of univerce, which reflected the socio-cultural values of the time. If it is reduced to a cognitive value, it can be said that logical consistency is given more weight.

However, in Newton's heliocentric theory, the stability of the universe was the central value of modernity to explain the phenomenon of the universe mechanically and causally, which significantly weakened God's power, rather than finding a purpose for a stationary earth-centered universe with divine boundaries. In the past, the world with boundaries was accepted without resistance. Nevertheless, it became socio-culturally difficult to accept with the advent of modernity. Naturally, these cultural factors conflict with the belief that with the existence of boundaries, the world maintains stability. As an alternative to resolving the conflict, it was stated that stability against planetary motion in the solar system can only be established when Newtonian law is in operation. Therefore, in Greece and the Middle Ages, as a paradigm acceptance standard, the perfection of the stability of the entire universe was realized as a paradigm acceptance standard. In modern times, the stability of the universe showed the accuracy of theories and data based on natural laws. It puts an important weight on the accuracy of the theory, which is a cognitive value.

This change of the times shows the ancient Greek spirit that values boundedness due to its stability, whereas, in modern times, it leans more toward neo-Platonism that emphasizes simplicity.

If a scientist decides on one of two competing theories, we can see through the history of science that choosing an algorithm for theory selection is not the only rational choice. Currently, we have two options: (i) changes in science are irrational; (ii) the commonly used concept of rationality is excessively demanding. In later writings, Kuhn supports the latter opinion. Although the paradigm shift is not irrational, a non-algorithmic weaker version is necessary to understand this paradigm shift in the concept of rationality (Okasha, 2016).

As a result of the scientific revolution, people accept the new paradigm, conduct problem-solving activities based on it, and clarify and develop a new paradigm. When the revolution is completed, another style of normal science begins based on a new paradigm. Additionally, if the new normal science progresses slightly, it inevitably encounters anomalous cases, faces a crisis, and is eventually replaced by another paradigm (Jang H.-S., 2014, p. 128). We reach some important conclusions about the changes in scientific theory seen through the changes in the structure of paradigms in the previous chapter.

First, notably, the theory is circular, but it is more discontinuous rather than continuous.

For example, for subsequent academic generations, the Copernican system had a strong appeal due to its "aesthetic simplicity," and Newton's system, which completed the Copernican system, explained it more precisely than Ptolemy's. Newton's system put mechanical questions about how a huge crystal ball can spin once a day, or cosmological questions such as what is outside the celestial sphere have become meaningless. In particular, the values—the criteria for theory selection—may overlap, but the metaphysical premises of the paradigm are discontinuous.

It was changing from a bounded and organic worldview for the unity of the universe of the ancient Greeks to the causal mechanical worldview of inert objects of modern times. The contemporary view is changing into a dialectical worldview that emphasizes creation and change.

Second, scientific theory repeats the revolutionary process with a new philosophy and theoretical system, as well as the cumulative development process by revising and improving theories. After the revolution, scientists have different interpretations of the same data by reinterpretation of data with new theories, which is a weaker meaning of Kuhn's phrasing that scientists conduct science in a completely different world.

For example, in the same solar system, the meaning of the two systems differs in the size and importance of the mass of the sun and the earth rather than in the difference in the vitality of the soul. In terms of mass, the difference between the Newtonian and Einsteinian systems is in the expansion of mass rather than in mass conservation.

In ancient Greece, vitality strives for self-realization, and in the Newtonian system, it is preserved like a machine, but Einstein's system dialectically emphasizes change and generation. Therefore, the interpretation can be different for the same data through a reinterpretation of data by a new theory.

Third, Kuhn sees truth as a kind of social consensus. It is a consensus and can be considered relying on perspective. There is no objective truth. There is only a kind of consensus on how accurate information is for a model (which is a kind of paradigm). Therefore, rather than being true, the system or model of knowledge should be discussed.

The revolution begins only after the emergence of alternative theories that solve numerous anomalous cases extremely impressively. However, rather than confirming all the problems previously solved, the revolution is completed first through an agreement by a group of scientists. The new Newtonian mechanics were initially recognized only in Britain, where experience was valued, but eventually expanded to the European continent. It can be said that the Enlightenment, a socio-cultural value at that time, influenced the consensus.

Newton's Principia was a commendable success in England upon publication. However, the concept of gravity became a problem on the continent. The concept of power by remote action, such as gravity and repulsion, was mainly used by alchemists and magicians at the time. Moreover, in areas under the influence of Cartesian philosophy, there was a strong backlash against Newtonian mechanics that recognized the power of remote action.

Nevertheless, Voltaire devoted much of his passion to introducing Newtonian mechanics to a wider audience in France. His "Elements de la philosophie de Newton" was the first book written in France about Newton to general intellectuals. Voltaire played a major role in the Enlightenment's spread in the 18th century by introducing Newtonian mechanics to French society.

Nonetheless, in my view, the accuracy of a scientific theory comes first and can be said to be in the cognitive value of simplicity. Thus, the initial non-cognitive value of the social consensus of the time eventually comprises intervention by cognitive value.

Fourth, it is not the accumulated growth of scientific knowledge, which is one of the basic beliefs. According to Kuhn, the paradigm of competing with each other is generally incommensurate. It is impossible for the concept of one paradigm or research achievement to be completely translated into another paradigm. The reason is to present a methodology of how to solve a given problem and present different ideas on how to understand natural phenomena, how to organize problems based on such understanding, and the form of answers to problems. Therefore, the paradigm that replaces a pre-existing paradigm through a scientific revolution is not a completely accumulated relationship in its explanatory ability.

However, if the creed of the impossibility of pledges is correct, this proposition has a different meaning for each; thus, there is no actual conflict between Newton and Einstein. There is a real contradiction between the two only when the proposition has the same meaning for both theories. As everyone acknowledges that Einstein's and Newton's theories contradict each other, it is a justification to doubt the impossibility of pledges (Okasha, 2016).

In response to this problem, Kuhn argues that a complete translation between the two paradigms is difficult but comparable. Therefore, I tried to avoid the criticism of relativism.

In particular, the consensus of a group of scientists is the selection of a problem and the resulting methodology. Of course, the ontology based on the socio-cultural values of the time is the basis. For example, what problem did you see in the movement of the pendulum?

Aristotle saw it as a restrained, falling active body, while Galileo saw it as the regular passive motion of a pendulum. For Galileo, the observer was a machine independent of the object, and empirical experiments were the method, but for Aristotle, the observer was not independent of the object, but rather an organism, so we only need to explain deductively without interfering with the motion. The value claim can be said to be logical consistency for Aristotle and empirical accuracy for Galileo.

## 5. CONCLUSIONS AND SUGGESTIONS

In the traditional view of science, as part of a process of our knowledge, the epistemological justification of scientific theory focuses on the accuracy of theory and data. If this accuracy also causes problems in the choice of theory, one can be referred to as a rationalist because it puts a standard on cognitive values, such as the simplicity of the theory. However, Kuhn's argument is one of naturalism and historicism, where the cognitive and non-cognitive values, such as the consensus of scientists, are important.

Normal science has a cumulative character, while the scientific revolution has a non-cumulative character (Kuhn, 1970, p). 184). Natural science seen through the history of science emphasizes the subjective "decision" among scientists' groups and accepts the role of social competition outside the theory formation process. It can also be called intersubjectivity. Above all, it can be said that it reflects the spirit of the times, which is a kind of worldview, as a socio-cultural element of the era. Essentially, scientific and cultural changes can also be said to be a scientific revolution.

The scientific revolution refers to a change in the overall worldview rather than simply a change in the concept of theory. It can be said that metaphysical beliefs, the implicit premise of propositional knowledge, which is the core of the worldview, play a significant role in influencing the paradigm as a whole.

Ultimately, the core of incommensurability is that direct comparison between scientific theories is not easy from a traditional scientific perspective. Scholars usually explain incommensurability by categorizing it into first, ontological, methodological, and semantic impossibility. In this study, the explanation was divided into the theory-ladedness of observation, the metaphysical and epistemological methodology, and the semantic impossibility in the socio-cultural background.

Ptolemy's geocentric theory that the stability of the solar system or the universe is the perfect circular motion around a fixed earth was part of the socio-cultural value at the time, which had the universal purpose of realizing heavenly perfection.

However, Copernicus' heliocentric theory, which was completed by Newton, embraced the motion of the earth. This was part of the modern socio-cultural value that explained accuracy in terms of causality rather than the purpose of the universe. The stability of a moving planetary solar system can only be established when Newtonian law is in operation. Therefore, in Greece and the Middle Ages, the realization of perfection for the stability of the universe was a standard of paradigm acceptance. In modern times, the stability of the universe was shown to demonstrate a world by natural laws and the accuracy of such theories and data that was almost clock-like. These theoretical selection criteria were a process made by changes in cognitive values and a combination of changes rather than relativism. These changing times are reflected in the ancient Greek spirit that values limits and stability, whereas in modern times, it was reflected through neo-Platonism which emphasizes simplicity.

A common standard that a group of scientists at a particular time believes to be important becomes the standard for paradigm selection. The paradigm is selected according to the social consensus of a group of scientists on the premise of metaphysical beliefs according to the socio-cultural and ethical values of the time. At first, there may be a non-cognitive value, such as social consensus, but eventually, the cognitive value becomes involved. In the traditional view of science, it was argued that these cognitive values intervene linearly to become a sort of algorithm. Kuhn's view is that such a process is not a linear algorithm but a rational process in which historically changing dynamic cognitive values are applied.

Kuhn himself was a pro-scientist like the logical positivists. His intention for expressing his belief in a paradigm shift, impossibility of pledges, and theory-ladenness(dependence) is not to weaken or criticize scientific management but to help us understand science better (Okasha, 2016).

Consequently, it shows us that looking at science from the perspective of Kuhn's paradigm allows us to understand and explore it more deeply. For example, it can reveal implicit metaphysical premises implied in scientific practice but not openly discussed by scientists. It cannot be said that the consensus refers to relativism because the social consensus of the scientific community at the time agreed on the choice of problem and methodology according to the changed paradigm.

It is worth drawing attention to this peculiarity at the outset as, overwhelmingly, it is Kuhn's (real or imagined) philosophy that had the biggest impact on science education.Amateurs can stumble on to truths, even deep ones, but a certain caution is sensible whenentertaining their views. This caution was rarely exercised by members of the scienceeducation community who were moved by Kuhn's philosophical pronouncements; in thewords of one review, the community became an "admiration society for Thomas Kuhn"(Loving & Cobern, 2000, p. 199).

Above all, the conceptual change in students' learning is very similar to the process of justifying scientific theories in the history of science (Oh, 2011, Oh,

## REFERENCES


Barnes, B. (1977). Interests and the growth of knowledge. London: Routledge & Kegan Paul.

Chalmers, A. F. (1999). What is this thing called science? (3rd edition), Cambridge: Hackett Publishing, Inc.

Chun, H.D. (2023). Thomas Kuhn, The Unfinished Revolution. Seoul: Seoul National University Press.

Cohen, H. Floris . The Scientific Revolution: A Historiographical Inquiry' Chicago: University of Chicago Press, 1994

Crespo, R. F. (2019). Liberal Naturalism and Non-epistemic Values. Foundations of Science, 24, 247-273.

Daston, L. (2018). Gegen die Natur (Against Nature).

Derry, G. N. (1999). What Science is and How it Works, Princeton University Press. Matthes & Seitz Verlag

Duhem, P. (1906/1954), La théorie physique. Son objet et sa structure, Paris: Chevalier et Riviere; translated by P.P. Wiener, The Aim and Structure of Physical Theory, Princeton, NJ: Princeton University Press,

Elliot, K. C. (2017). A Tapestry of Values: An Introduction to Values in Science(First Edition). London: Oxford University Press.

Feyerabend, P. K. (1975). Against method. London: New Left Books.

Fischer, F. (2000). Citizen, Experts, and the Environment: The Politics of Local Knowledge. Durham: Duke University Press.

general relativity based on the philosophy of Science. Nova Science Publishers Inc. https://doi.org/10.52305/QCRK1611

Giere, R. (1993). Science and Technology Studies: Prospects for the Enlightened Postmodern Synthesis. Science, Technology & Human Values, 18(1), 102-112.

Hanson, N. R. (1958). Patterns of Discovery an Inquiry into the Conceptual Foundations of Science. New York: Cambridge University Press.

Henry, J. (2012). A Short History of Scientific Thought. UK: Palgrave Macmillan.

Hess, D. J. (1997). Science Studies: An Advanced Introduction. New York: New York University Press. (Translated by Kim Hwan-seok, 2004, Understanding Metascience, Seoul: Dangdae Publishing Co. Korean Translation Copyright)

Hewson, P. W. (1985). Diagnosis and remediation of an alternative conception of velocity using a microcomputer program. American Journal of Physics, 53, 684–690.

Hewson, P. W., & Hewson, M. G. A. B. (1992). The status of students' conceptions. In R. Duit, F. Goldberg, & H. Niedderer (Eds.), Research in physics learning: Theoretical issues and empirical studies (pp. 59–73). Kiel, Germany: Institute for Science Education at the University of Kiel.

Hossenfelder, S. (2018). That New Theory of Everything is Lost in Math!

Kosso, P. (2007). Scientific Understanding. Foundations of Science, 12, 173-188.

Kuhn, T. S. (1962). The Structure of Scientific Revolutions, Second edition(First Edition). Chicago: University of Chicago Press.

Kuhn, T. S. (1970). The Structure of Scientific Revolutions(Second edition). Chicago: University of Chicago Press.

Kuhn, T. S. (1987). What are Scientific revolution ?. in I. krüger, I. J. Daston and M. Heldelberger (Eds.), The Probabilistic Revolution, Vol. Ⅰ: Ideas in History, Cambridge, MA: Mit Press.

Kuhn, T. S. (ed.)(1977). The Essential Tension: Selected Studies in Scientific Tradition and Change. Chicago: University of Chicago Press

Oh J. -Y. (2012). Kuhn's interpretation of the development of the cosmology of the solar system from the perspective of science education to foster the nature of science (NOS), Korea Philosophy of science, 15(2), 25-65.

Oh, J. -Y. (2011). Using an Enhanced Conflict Map in the Classroom (Photoelectric Effect) Based on Lakatosian Heuristic Principle Strategies. International Journal of Science and Mathematics Education, 9(5), 1135-1166

Oh, J.-Y. (2022). Conceptual features of Einstein's theory of

Okasha, S. (2016). Philosophy of Science: A Very Short Introduction(second edition). Oxford, New York: Oxford University Press.

Posner, G. J., Strike, K. A., Hewson, P. W. & Gertzog, W. A. (1982). Accommodation of a scientific conception: toward a theory of conceptional change. Science Education, 66(2), 211-277.

Preston, J. (2008). Kuhn's "The Structure of Scientific Revolutions": A Reader's Guide. United Kingdom: Bloomsbury Publishing PLC.

Reiss, J., & Sprenger, J. (2014). Scientific objectivity. The Stanford Encyclopedia of Philosophy. https://plato.stanford.edu/entries/scientific-objectivity/. Accessed 18 May 2020.

Sharrock, W., and Read, R, (2002). KUHN: Philosopher of Scientific Revolution. Malden, MA: Polity.

Tyson, L. M., Venville, G. J. Harrison, A. G., and Treagust, D. F. (1997). A Multidimensional Framework for Interpreting Conceptual Change Events in Classroom. Science Education, 81, 387-404. Zwart, P.J. (1976). About Time: A Philosophical Inquiry Into the Origin and Nature of Time. American Elsevier Pub. Co.