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### **Original Research**

# Understanding the Theory of Einstein's Special Relativity Based on the Coherence of the Theoretic System

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# Abstract

Weinberg (1992) supported "Rigidity in physics theory". This is a method which does not allow even the smallest quantity of change without a large scale overturning in the coherence network, and represents solidity at a level where the pieces of the theories themselves can be pieced together. In order to maintain coherence between theories, it is an inevitability and necessity for the solid description of theories of nature. Assumptions and premises, which are important elements comprising conceptual frames, play an important role when we form new concepts. The process of the coherence between component theories in a conceptual frame increasing through these assumptions or premises functioning as axioms to derive new theoretical theses is a characteristic of the formation process of the principles of Einstein's special theory of relativity. The purpose of this study is to make a proposal regarding appropriate education of the special theory of relativity through this process of increasing overall coherence. It is a cyclical and ecological learning method and not a linear and mechanical learning method. The research problems following this purpose are: preliminarily, to understand the characteristics of Einstein's special theory of relativity which has coherence between all the theories, and ultimately, to make a proposal on the education of the special theory of relativity to make a proposal on the education of the special theory of relativity to make a proposal on the education of the special theory of relativity.

Keywords: Coherence; Special theory of relativity; Rigidity; Conceptual frame; Axiom.

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# **1. Introduction**

Why Scientific Literacy is important?

A number of different reasons can be made to convince you scientific literacy is important. We call then as following (Hazen and Trefil, 2009).

First, the features from civics

Second, the features from aesthetics

Third, features from intellectual connectedness

From the perspective of a citizen, we live our lives constantly facing problems which require scientific background knowledge. Therefore, everybody needs a certain level of scientific literacy.

In recent decades, science education has been discussed internationally in terms of concepts such as "science for all" (Fensham, 1985), "science, technology, and society" (STS) (Solomon and Aikenhead, 1994), "public understanding of science" (Fensham and Harlen, 1999), "scientific culture" (Solomon, 1998), or "scientific literacy" (Bybee, 1997). Although there are differences between these concepts (Burns *et al.*, 2003) they all seek to link the content and aims of science teaching to what average citizens need in order to participate effectively in a society that is highly dependent on science and technology. Indeed, understanding the needs of citizens is central to all these notions.

Chandrasekhar (1987), suggests scientists find motivation and desire to participate in science through aesthetics, and McAllister (1996) appeals to aesthetics as a critical factor in a highly rational account of scientific progress and revolution. This aesthetic aspect is the result of an elegant world view which applies scientific laws that was gained through the efforts of scientists over several centuries, and the fact that all phenomena have a certain consistent commonality gives us intellectual and aesthetic satisfaction. Those who are scientifically illiterate are missing out on a very fruitful part of life. This is because the aesthetic aspect provides research motivation for the sciences, and influences judgement and the research methodology of scientific theory. In addition, it is because it can have an impact on the learning motivation of students. Various authors writing from modern, foundational stances discuss traits or qualities within objects of science as beautiful or artistic. In this regard, commonly cited qualities of beauty are simplicity, symmetry, pattern, and unity of structure (Girod, 2007). Therefore, this research focuses on the simplicity, symmetry, and unity between theories as major aesthetic appreciation through aesthetic experience to maximize powerful learning. This is a science education proposal utilizing the aesthetic process of increasing overall coherence. It is a cyclical and ecological learning method and not a linear and mechanical learning method.

From the perspective of intellectual continuity, the 'zeitgeist (worldview)' is something that is greatly affected by the scientific development at that time. It is a well-known fact that scientific discovery determines that intellectual

atmosphere of an age. For example, Newtonian mechanics played a crucial role in dispelling the old thinking of the Middle Ages to bring about the Age of Enlightenment, when Darwin discovered the principles of natural selection people came to understand that worldly affairs were not taking place following the plans of God, and quantum physics taught us that the world does not behave totally rationally.

One of the methods that scientists use to determine the reliability of a theory is to appeal to the beauty of the theory. The most generalized element of such beauty is symmetry (Kosso, 2011). Einstein at the age of 26, in the early 20<sup>th</sup> century, demolished the classical physics of Galileo and Newton. The new thinking on time and space was the result of looking at nature purely from the perspective of symmetry. By departing from Newton's mechanical perspective of the 19<sup>th</sup> century and based on 20<sup>th</sup> century physics laws we moved toward the elegant principles of symmetry and simplicity. Symmetry means the constancy in the form of the laws of science regarding any change in time and space. In addition, it is the aspect by which the possible premises supporting a scientific theory are logically simple.

Above all, education on the aesthetic aspect through the increase in coherence is needed.

Science textbooks on scientific methodology are focused on handling individual concepts. They show strict empiricism. It is how a hypothesis is proposed from as much data as possible, and testing that through expected data. It is only focused on the correspondence between a certain theory and evidence, and almost never emphasizes the connection between that theory and other theories (Kosso, 2011). Therefore, regarding Newtonian mechanics and Einstein's special theory of relativity which are essential in the modern age, we need to explore them focusing on metaphysical trust which is the conceptual frame that we use to understand nature, and the cognitive values which become the standard for scientific theory research and selection based on that conceptual frame.

Starting from the simple assumption that together with the observation tool which is observed at the constant speed of light, all observers move at a constant speed, from the common sense perspective of Newton's universe where time and space are absolute and independent, the space time of Einstein is one where the invariability and logical necessity of the law of physics follows the relation of symmetry that affects each other. In addition the equivalent relation of mass and energy is the conclusion of the logical necessity of the speed of light being the speed limit that all objects can have and causal relationships.

In order to achieve these research goals I have set the following research problems.

First, what is the beauty of the theory that was pursued by Einstein which is symmetry, simplicity, and logical necessity? Second, how is Einstein's conceptual frame different from the frame of Newtonian mechanics? Third, how does coherence, which shows the aesthetic perspective of the theory for educational purposes, appear in Einstein's special theory of relativity?

# 2. Backgrounds

#### 2.1. The Concept of Coherence in Scientific Methodology

The concept of coherence in a network of ideas is playing an important role in this account of scientific method, and it deserves as much precision as possible. The most basic requirement of coherence is logical consistency. A network of scientific knowledge cannot tolerate contradiction. This is not to say that there are no contradictions lingering in the sciences, but where they are identified they must be addressed. Contradiction cannot be ignored. Scientific claims must not only be consistent, they must be cooperative. This is less precise than logical consistency, but it requires not just compatibility in the network of ideas, but connections among the ideas. Theoretical claims explain observations, and sometimes they explain other theoretical claims. One theory participates in the role of auxiliary in accounting for the evidence of another theory. And so on. There is a variety of kinds of links between scientific ideas. And building such an inter-related, coherent web of claims is a challenge and an accomplishment (Kosso, 2011). Coherence is descriptive of a whole system of beliefs and indicates that the constituents fit together in some way. It describes the relation between one belief and beliefs. Correspondence describes the relation between one belief and the world. It's one thing for one belief and other beliefs. ... This distinction between coherence and correspondence is very similar to the separation of internal and external features (Kosso, 2011). Theories may also have aesthetic virtues. Because of its symmetry or the elegance of its models, a theory could be appealing to the eye. These features just make it look good. The feature of being simple could be doing double duty here. It could be both a pragmatic and aesthetic virtue (Kosso, 1992).

The basis of properly carrying out a belief is understood under the premise that it confirms that belief. In other words, the relationship between belief and the basis of epistemic justification in question has a demonstrative structure of premise and conclusion respectively. Rather than using all beliefs that compose an individual's belief system as premises, just one or a few of those beliefs are used to justify the belief in question. The linear coherence theory is formed when sensible opinions regarding inferences such as the coherence theory are accepted and the rules of coherence are reflected. According to the linear coherence theory, if a belief becomes justified when other beliefs within a certain range of that belief's subject are considered, the belief is systematic and coherent, and thus becomes justifiable. On the other hand, if all other beliefs that compose one belief system must be considered as a premise in order to justify the belief in question, there may be an argumentative coherence theory. This type of coherence theory is called "holistic coherence theory". Based on the holistic coherence theory in order for a belief to become justified through a justification of the system, all beliefs in the belief system must be justifiable when they are considered. The holistic coherence theory 00may be regarded as being stronger than the linear coherence theory (Kim, 2005). As the hypothesis comes into equilibrium within the network of scientific knowledge, there is more and more good reason to believe it is true. This is the scientific method (Kosso, 2011).

Coherence between Holistic Theories through Understanding: "The intellectual architecture that Toulmin talks about is found in the structure of relations among theories. This is what is needed to not merely know about nature, but to understand it as well." (Kosso, 2011) "Theories may also have aesthetic virtues, Because of its symmetry or the elegance of its models, a theory could be appealing to the eye. There features just make it look good. The feature of being simple cold be doing double duty here. It could be both a pragmatic and aesthetic virtues. ...... There are also psychological virtues. If a theory has the property of giving us a feeling of understanding, of explaining something so that it now makes sense to us, it has psychological virtue"(Kosso, 1992). All of these ways of considering scientific understanding, from student testing to beauty to theoretical rigidity, suggest the same general idea. And the achievement of understanding is in apprehending the connections between theories and global coherence among concepts (Kosso, 2007). To understand means to be combined with occasional scientific explanations. Wesley Salmon, for example, acknowledges that "we have scientific understanding of phenomena when we fit them into a general scheme of things" (Salmon, 1998). According to Salmon, explanation, requires that this scheme be explicitly about the causal connections between events. Knowledge of causal connections can certainly contribute to understanding, but it is, strictly speaking, neither necessary, as there are other kinds of links in the scheme, nor sufficient, since it the global, multi-linked nature of the scheme that amounts to understanding. Philip Kitcher's account of explanation and understanding is less specific about the content of the scheme and more attentive to the structure. Explanation and understanding are achieved when the scheme is unified, covering many kinds of phenomena with few "patterns of derivation" (Kitcher, 1989). The derivations in Kitcher's account are strictly deductive, narrowing his description of explanation in a way that it misses other kinds of structural connections that could facilitate understanding. The intellectual architecture that Toulmin talks about is found in the structure of relations among theories. This is what is needed to not merely know about nature, but to understand it as well (Kosso, 2007). Rather than accuracy, which is the objective of modern science that led the scientific revolution (Toulmin, 1990), important standards that judge aesthetic theories include simplicity, symmetry, and necessity (Kosso, 1999). McAllister (1996) argued for one important aesthetic influence with respect to determining each individual's theories through truth and lies by referencing various factors such as simplicity, symmetry, and unity. Scientists already believe this, and reference these when deciding upon new theories. Kosso (2007) claimed that aestheticism is related to understanding. Understanding, aestheticism, and theoretical coherence are related concepts. Further, they make an important roles in the valuation judgment process, which is the aim of science.

#### 2.1.1. Coherence and Necessity

The difference between the necessary and the contingent is recognized from the perspective of our theoretical framework. The decisive factor is theoretical rigidity, which is, being firmly tied into the conceptual web such that changing the one feature of nature has far-reaching consequences (Park, 2011). Weinberg (1992) supported epistemic value, which is the "rigidity of the physics theory". It is a method that does not tolerate even the slightest change without a large scale turnover in the coherence network, and it is rigid to the point where each piece of the theory can be mixed and matched. It is a type of necessity or inevitability in theoretically rigid techniques regarding nature for maintaining consistency. Necessity has a many characteristics of a wide range of connections through facts. It is a type of coherence. We may understand necessity as a non-experiential concept that is induced by a connection to a theoretical system. More observations may lead to more knowledge, but this does not necessarily lead to more understanding (Kosso, 2007). For example, there is an important difference between Bode's law and the absolute principle of the speed of light. Many things are concluded in the absolute principle of the speed of light through the combination of time and space, increase in mass, and mass-energy equivalence. However, Bode's law hardly contains any related content. It is this lack of theoretical coherence and rigidity (Kosso, 2011). Steven Weinberg, a Nobel Prize winning physicist, offers a helpful characterization of beauty in physics that is similarly linked to our sense of understanding. He promotes the epistemic value of "the rigidity of physical theories". Theories are rigid to the extent that their pieces fit together in a way that no small detail can be changed without large-scale disruption in the coherent network. There is a kind of inevitability and necessity in a theoretically rigid description of nature, in the sense that the values of parameters and the structure of interactions must be as the theories describe them, in order to maintain consistency and connections in nature.

As an example of theoretical rigidity, Weinberg cites the fact that the force of gravity decreases as the inverse square of the distance between two objects. In the context of Newtonian theory, the inverse-square relation is empirically motivated. It is put in the field equations to accommodate observations of planetary orbits. It could have been an inverse-cube, if that was what was needed to save the phenomena (Kosso, 2011). Therefore, necessity is a global property of extensive connections among facts. Necessity is a kind of coherence (Kosso, 2011).

Since we are looking for a general pattern in the logic of indirect empirical testing, it will help to symbolize Einstein's argument. Let H stand for the hypothesis in this, or any other, case of empirical testing. Let p stand for the implication, that is, the prediction. In the particular case of testing the general theory of relativity (Kosso, 2011),

H = Space and time are curved.

p = Light rays will bend when they pass near the sun.

Then Einstein's reasoning is in the form of an if-then statement:

If H is true, then p will be true.

Or, even more briefly:

If H then p

This kind of statement, if H then p, is the central premise of indirect empirical testing. Since it is a case of deducing the prediction p from the hypothesis H, any test that involves an if-then statement like this is called

hypothetico-deductive testing. The complete test requires observing whether the prediction p is true or not. In Einstein's case, the prediction turned out to be true. But, the inductive route from observation to theory cannot be all there is to science. There will have to be a flow of information back-and-forth, from theories to observations and from observations to theories, from inside-out and outside-in. The important role of empirical evidence may come after the idea is proposed rather than before (Kosso, 2011). The invention of new theses or the continuous explanation of new phenomena demonstrate the phenomena that compose Einstein's theory, particularly the fact that there is necessity between theories.

#### 2.1.2. Coherence and Symmetry

Symmetry in physics was discovered by relying on the intuition that substantial domains that permit conversions exist. Advancement in physics comes from the understanding that things occurs in combination. Just as Newton combined the earth and planetary dynamics into one, combining more phenomena under a given law is how science advances (Yanofsky and Zelcer, 2017).

What Einstein regarded with importance was belief regarding physical combination and belief regarding the symmetry (conformity) of information acquires from various domains of physics accordingly. If the speed of light is consistent in a given system, it must be consistent in other system (Fischer, 2001). The laws of physics are consistent and do not change with the passing of time. For example, if Galileo's conversion is adopted, the nonrelativistic Newton's dynamics are acquired. However, light is not consistent with actual values that are measured. On the other hand, if Lorentz's conversion is adopted, Einstein's relativistic dynamics are acquired. Lorentz's conversion involves a conversion equation that satisfies the condition that light is constant despite changes in time space coordinates, and this relativistic dynamics are forfeited, the light of light will take an absolute position. Similarly in mathematics, symmetry was discovered when other mathematical phenomena were found to exist in the range of known conversions, and this resulted in putting it in a wider range (Yanofsky and Zelcer, 2017).

The special theory of relativity includes Galileo's principles of relativity, but it is more accurate. In other words, movements that are slower than the speed of light give similar results to that of Galileo's principles of relativity, but this theory provides a more accurate explanation regarding movements that are similar to the speed of light, which cannot be explained by Galileo's principles of relativity. If Lorentz's conversion is selected by revising Galileo's conversion from classical mechanics to fit electromagnetism, absolute space and absolute time must be forfeited, hence time and space must have relative positions in order for the speed to light to have an absolute position. However, if speed happens to be slow, Galileo's conversion is included. Thus, the phrase, "speed of light is the same for all observers," shows that the relativity theory is abstractly aesthetic as a new symmetry. However, this paper must be reinforced because it lacks content regarding symmetry. This is because a direction of coherence is proposed.

#### 2.1.3. Coherence and Simplicity

If the postulate that a god exists in monotheism, a metaphysical justification regarding the laws of simplicity will take place. However, if a god is infinite in all aspects, the thesis that "god truly exists" may be the most complex hypothesis that we can deliberate. Considering this, selecting any other alternative hypothesis from those that explain facts in this world will be simpler than this hypothesis. The second explanation is that it is purely inductive. In inductive reasoning, the conclusion may show that a considerable degree of probability or potential is secured, but it cannot argue certainty for the future (Beardsley and Beardsley, 1972). In another explanation, a simpler hypothesis not only has less risk of conflict with observations because less assumptions are made, if the hypothesis (Beardsley and Beardsley, 1972). Newton made intuitive metaphysical implements under the assumption that God is infinite and perpetual, but Einstein's theory of special relativity is contained in Maxwell's electromagnetic theory. The symmetry that bundles all conflicting phenomena for the constancy of the speed of light in the inertial system as shown in tests conceptually shows greater relative simplicity than Newtonion dynamics.

While this isn't clearly addressed in the book written by Kosso (2011), simplicity must be mentioned because it is an important factor from an aesthetic perspective. Advanced physics is inherently much simpler in concept than elementary physics. The secrets of nature are not easily revealed to beginners. Many give up on physics at the high school or university level because countless phenomenality equations are proposed. These phenomenality equations have no relation to aesthetics, symmetry, or fundamental simplicity, which are the basis of nature (Zee, 2007). Ultimately, what stands out most in this book is that Einstein's special theory of relativity shows necessity because holistic coherence increases between theories with internal consistency rather than Newtonian dynamics that show experiential accuracy as external consistency. Above all, it shows how interesting the aesthetic aspect of theories are through understanding scientific theories rather than scientific knowledge. We can also understand what is necessary, but only by attending to the non-empirical, derived links in our systems of theories Kosso (2011). However, Newton required absolute time and space that moves objects with a set mass, but Einstein required relative time and space with symmetry by combining conflicting theories. In other words, the core question lies in which set of coordinates that are apt for presenting and discussing a theory will be considered.

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	Esthetics in Science, Internal Features	Knowledge in Science, External Features	Psychological Virtue,
Kosso (2011), Scientific understating considerations	Global Coherence	Correspondence (Kosso, 1992;2011)	the achievement of Understanding is in apprehending in global coherence (Kosso, 1992;2011)
McAllister (1996), esthetic influence for justification	simplicity, symmetry, unity		
Weinberg (1992)	simplicity, symmetry, theoretical rigidity (inevitability and necessity)		

Table-1. Scientific understating considerations in scientific method

# **2.2.** Role of Thought Experiments and Mathematical Abstraction in the Special Theory of Relativity

Albert Einstein formed his theory through thought experiments and mathematical abstraction, not through direct experiments (Miller, 1993). Some thought experiments include inductive reasoning, while other ones include deductive reasoning. In other words, there are two types of thought experiments: constructive and destructive. A destructive thought experiment is an argument directed against a theory. At least, such a thought experiment causes tension between a theory and other alleged well-organized fundamental theories by showing flaws of the theory itself, which clearly conflict with the fundamental theories.

The boy Einstein wondered what it would be like to run alongside a light beam. It seemed to him that the light beam would appear to halt. However, this boyhood question about light confronted contradiction. 'Light stopping', which is possible according to Newtonian mechanics, means a nonvibrating electromagnetic wave that clearly conflicts with electromagnetism. Besides, according to Maxwell's electromagnetic theory, the velocity of light in vacuum is derived to be a constant value (Brown, 2010). We can see that such a simple question of the body Einstein was one of the main motivations for relativity theory.

In 1905, when Einstein was 26 years old, he attained the solution of his boyhood question about light. The principle of constancy of light velocity, which is based on the electromagnetic theory, overthrew the common sense idea of velocity. In other words, common sense about distance (space) and time, which measure velocity, was subverted. Einstein utilized the electromagnetic theory to point out a contradiction of classical mechanics and proposed the special theory of relativity showing new symmetry. The existence of ether was denied. We may guess that from early on he had the peculiar idea that the velocity of light is constant.

On the other hand, other physicists including Lorentz and Poincaré considered ether space to expand the electromagnetic theory. Lack of thought experiments in childhood might have led them to expand the electromagnetic theory without destroying Newtonian mechanics.

In addition, although Einstein found and used the equation of a Dutch physicist, Lorentz, he grasped this same change by means of his own thought experiment (Zukav, 1979). He conducted a thought experiment about time and space only on the basis of the principle that the velocity of light is constant. This thought experiment included 'optical clock'. Thus, we can classify this experiment as a mediative thought experiment that belongs to constructive thought experiments according to Brown (2010). From a well-recognized plain theory (the principle of constancy of light velocity), a new conclusion (new idea of space-time) could be derived. Besides, there are geometrical diagrams (triangle) that are useful to understand and find out the derivation of a formal and mathematical invariant (from Galileo conversion to Lorentz conversion).

However, I think this thought experiment was not only the process of destroying a theory and building another one but also combined two theories by physical symmetry. According to the principle of constancy of light velocity, which was derived from the electromagnetic theory, the Galileo conversion was modified so that physical symmetry was replaced by mathematical symmetry, which corresponded to Lorentz conversion. In this process, the 'optical clock' thought experiment had continuity. It can also be classified as a Platonic thought experiment of destruction and construction (Brown, 2010). The beauty of Einstein's special theory of relativity consists in symmetry, simplicity and logical necessity. Scientists agree that physical symmetry supporting every observed area and Lorentz conversion enduring every change in the space-time coordinate are among the most beautiful theoretical things.

Einstein showed in his thought experiment that simultaneous events to us are not simultaneous in the following way.

"Einstein thought he was not a 'revolutionist' but a 'successor'. In fact, he spoke clearly that he inherited the electromagnetic program originated from Faraday and Maxwell. His awareness that the electromagnetic theory and mechanics of the time did not satisfy symmetry condition was a crucial motivation for the special theory of relativity. The principle of relativity, which Einstein insisted all his life in theoretical works, is a kind of symmetry principle. Specific issues like simplicity of nature and symmetry of theory provide important motivations both for

evaluating a scientific theory and for conducting a scientific research based on the validity of the theory (Holton, 2000).

# **2.3. Dialectical Materialism in the Scientific Methodology of the Special Theory of Relativity**

Dialectical thought: Einstein possessed profound dialectical institution. He not only depended on the dialectical method consciously but also utilized it creatively. His theory was based on the dialectical thought that is different from a metaphysical view that nature has universal interconnection and unity.

Materialism: Einstein had materialistic attitude to the main problem of philosophy, that is, which one is primary among mind, sensation and human world. He did not doubt that nature preexists humans and nature does not depend on sensation or mind. He also did not consider the problems of origin such as the origin of scientific concept, category, scientific law and mathematical proposition separately from material world. Another main problem of philosophy is about the recognizability of world. Einstein thought the understanding of the external world is very important issue and he did not forgive his belief that human reason would disclose secrets (of the external world). "The basics of every scientific research consist in the belief that the world is orderly and can be understood" (Gribanov, 1987).

Einstein's dialectical thought overcoming Newton's metaphysical view: Many metaphysicians thought the external world itself and the objects in it are immutable in time. Accordingly, they took it for granted that the world reflected in scientific concepts and theories has a perfectly and absolutely immutable form (Gribanov, 1987). For instance, if the world is understood by Newtonian mechanics, which is a fixed and finite scheme, 'qualitative change' is impossible. The Newtonian mechanics cannot explain the evolution of living things that change and develop in a long history. The mere change of locations of matters due to external forces is not sufficient to evolution. In this regard, the Newtonian mechanics is a metaphysical view of the world.

Unlike the metaphysicians, Einstein emphasized the continuity of physical theories. Each stage of scientific development adds a new element for constructing absolute truth. However, what claim is contained in each scientific argument is a relative matter and only the scope changes along with the growth of human knowledge (Gribanov, 1987). In the inertial reference, the principle of constancy of light velocity and the principle of relativity are the basis of the special theory of relativity. It was because these principles were considered as the most basic principle reflecting real process of nature and connecting fields and particles, which are two domains of material world. The principle of constancy of light velocity is concerned with both domains, while Galileo's principle of relativity in the inertial reference deals with particles. The special theory of relativity combines these two physics. The electromagnetic theory was formed while the classical mechanics was still dominant among scientists. However, the principles were inconsistent from the point of the classical mechanics. Newton's metaphysical materialism could not provide any consistent explanation between the properties of field and the concept of matter (Gribanov, 1987).

It was a great success and the beauty of the Newtonian mechanics that every motion of matter could be accurately predicted by its laws and initial conditions. The Newtonian mechanics itself was a great improvement of human intelligence and encouraged humans a lot.

Metaphysical worldview is opposed to dialectical worldview. Newton's physical principles had a great advantage in intuitive explanation and he made them a pure scientific theory that is a metaphysical entity. However, he could not guarantee such metaphysical assumptions. It seems that this flaw anticipated Kant's transcendental aesthetic and Einstein's new theory.

#### 2.4. Time and Space: Newton's Metaphysics and Einstein's Dialectical Explanation

Metaphysics has as Its aim the characterization of our conceptual scheme or conceptual framework. The structure of the world as it is in itself is inaccessible to us and metaphysicians must be content to describe the structure of our thinking about that world (Loux, 2002). However, although independent from conceptual scheme, we can grasp them only when they are represented through a conceptual structure (Loux, 2002). Metaphysics is a conceptual scheme or frame representing the external world. Therefore, we think Kant's metaphysical explanation of time and space is adequate.

In Kant's transcendental aesthetic, our conceptual acts, where the understanding operates, are eliminated from cognition. When the concept of apple is removed from fruit, sweetness, red color, roundness, etc. are left and Kant called these empirical intuitions. Further, if the empirical aspects are eliminated from the empirical intuitions, what would be left? When every experience is removed from empirical intuitions, pure intuitions are left. Space and time as pure forms are the very pure intuitions. To explain a concept is to discuss, argue or advocate the concept. If concepts to be discussed and argued turn out to given a priori, this is metaphysical explanation. Such metaphysical explanation is divided into theory of space, which is the explanation of space, and theory of time, which is the explanation of time (Jeon, 2016).

#### 2.4.1. Theory of Space

Unlike empiricists who argued the concept of space is built from our experiences, Kant thought space is not empirical but transcendental.

1. Space is not an empirical nor dianoetic concept made by abstracting common features from external experiences. Rather, external experiences are not possible without representation of space.

2. Space is the necessary representation underlying every external phenomenon thereby being unable to be eliminated.

Unlike rationalists who argued space belongs to the understanding and is possessed inherently by the reason, space is represented as the one and the only space before as having partial space. Thus, space is not a representation of the understanding but the only whole representation. In other words, space belongs to the intuition, which is the domain of sensibility.

3. As long as space is the one and the same space, it is not a concept but representation.

4. Space is not a concept since it is a representation with infinite magnitude.

# 2.4.2. Theory of Time

Time is not inferred from experiences, but every object can be represented by assuming time.

Time is a necessary representation that cannot be eliminated from the phenomenon in general (external and internal phenomena).

Principles of time are given to us prior to experiences.

Time is the only and the same time. In this regard, time is neither an inferred nor a general concept.

Time cannot be a concept since it is an infinite representation.

According to Newton's mechanical view of nature, which was dominant between 17th and 18th century, things are grounded on simple mechanical principles and thus were considered to move mechanically. Accordingly, there was no qualitative change but only quantitative one. This world was not flexible and neither development nor evolution was considered. It was a metaphysical belief that did not include qualitative change.

The academic world was not exceptional in being affected by the idea that everything exists depending on simple and logical rules. Every human being has natural rights to be respected. In addition, according to the Newtonian law saying future is determined by present, the cosmos is similar to an enormous clock, which leads to a doctrine of predestination (Spielberg and Anderson, 1995).

The historical significance of the special theory of relativity consists not only in refining laws of mechanics but also in discarding the metaphysics of the Newtonian mechanics. Time and space are the assumptions of physics and are given to us prior to every concept. Kant argued that time and space as the basis of our cognition are a transcendental form. On the other hand, when Einstein introduced the new space-time into his special theory of relativity, he clarified that the space-time was not given absolutely a priori but constructed from experimental data and was related to the motion of an observer who is a cognitive subject.

One of the characteristics of Newtonian transcendental metaphysics is that the world is immutable. Something changeless is set in advance and material movement are understood accordingly. In this dualistic and mechanistic thought, time flows, of course, but it is also immutable.

However, the dialectical worldview understands the world not to be an immutable thing but to change and develop. The evolution theory revealed that living things continue to change and develop through the correlation between genes and the environment. Hegel regarded opposition as the cause of change and development. The Newtonian mechanics showed some flaws as the basics of physics and thus it had to be modified along with the development of physics. Consequently, Einstein's theory of relativity broke down the Newtonian transcendental metaphysics and began to grasp the world by the dialectical worldview. As the dialectical thought could be a conceptual frame to understand the world, it took the place of metaphysical concepts.

#### 2.5. Coherence and Education

Dynamics of learning can be described well by fractal image, not by traditional Euclidian images, that is, line, arrow and area. The fractal image is a kind of feedback loop where one image is made by being elaborated recursively and the product of the previous stage becomes the input for the next stage. This process in itself continues to change but the 'memory' of the previous stage is preserved without modification. The network structure expanding from a smaller node to a larger one is not only a knowledge producing system including brains, social groups and internet network (Calvin, 1996) but also is useful for explain already produced knowledge systems such as language, mathematics and science (Davis *et al.*, 2008).

The last 20th century was dominated by a causal point of view, in other words, a linear point of view arguing that learning is the product of teaching. This conceptualization made teaching and educational course understood mechanistically. However, such an idea began to change gradually. Learning began to be understood from a more holistic, indeterminate and exploratory perspective. The traditional correspondence-based approach included behaviorism and psychologism and was an attempt to apply scientific concepts complying with causal relation to reality, while the new coherence-based approach corresponds to constructivism and ecology and thus is more related to adaptation, evolution, adequacy and sufficiency than causal relation (Davis *et al.*, 2008).

Correspondence-Based Approach(Mechanical)	Coherence-Based Approach(Ecological)	
Newton's classical mechanics	Einstein's special theory of relativity	
Mechanical metaphor	Ecological metaphor	
Linear image	Circular image	
Flow of input/output	Feedback loop	
Efficiency oriented	Sufficiency oriented	
Goal-oriented	Growth-focused	
Transcendental assumption with no change	Dialectical historical change is assumed	

Table-2. Relationship Between Correspondence and Coherence from Educational Perspective

The details of the comparison between two theories are presented in the next section.

# **3.** The Worldview of Einstein's Special Theory of Relativity as Seen through the Conceptual Frame Proposed by Einstein



In a 1952 letter to his lifelong friend Maurice Solovin, Einstein expressed his philosophical opinion on science in the form of a diagram. In the diagram, E refers to the data that we have, A refers to the System of Axioms of physics, and S, S', S"... refers to the theorems deduced from the system of axioms (Hong, 2008). Therefore, in this study I have used the conceptual frame proposed by Einstein. Definitions of basic terminology are given, and then from those, axioms, which are obvious truths, are described. Various laws are gained based on these axioms. We can say it is a system of theories. In this study, these various laws are fed back into new axiom systems to create other laws. In Newtonian mechanics it appears not as a cyclical but a linear relationship.



Not only can the laws of physics be applied in same way as the classical laws of Newton, for the inertial frame of reference where all things move at the same speed, using a mathematical conversion called the Galilean transformation, but physical quantity is also the same. For example, the same universal gravitation is applied. However, the laws of electromagnetism proposed in the mid-19<sup>th</sup> century by Maxwell (1931-1879) could not be applied using this Galilean transformation. The laws of electromagnetism which is applied in states where objects are moving at different speeds were different. For example, a moving charge creates electromagnetic force based on a different speed.

Figure-3. The Process of Formulation for the Theory of Einstein's Special Relativity Based on the Lorentz transformation



Newton believed that time and space could be expressed using an independent orthogonal coordinates system. He considered time and space to be independent variables. That is he was asserting the absolute nature of time and space. However, Einstein shows that in an inertial frame of reference the constant of the speed of light reveals the Lorentz transformation which shows that space and time are not independent but connected to each other. Einstein rather than accepting the conservation of ether proposed by Lorentz, completely ignored it and in 1905 announced the so-called special theory of relativity. If we continue to apply the relationship between work and energy in this Lorentz transformation, it formalizes the famous conclusion of mass and energy equivalence.

What is interesting about Einstein's special theory of relativity is the fact that it combined the two totally different conceptual systems of Newton's mass and Maxwell's electromagnetic wave to formalize a totally new special theory of relativity. Historically, the combination of two opposing systems of different qualities, and quantitative increase in extreme circumstances not in everyday life, are examples of dialectical methodology which brings about new qualitative change. It is different from the metaphysical perspective of the quantitative world like Newton's where the same types of mass are adhered to. In addition, departing from the idealism of Kant which states that objects themselves cannot be understood, it is an example of materialism which states that we can understand objects using our human reasoning.

Following the opinion of Kant who stated that rather than the classical meaning, it has an important role in the formation of concepts as a conceptual frame, I drafted a conceptual frame as follows.

#### **3.1. Metaphysical Belief**

As in objective nature, organized order and causality including us humans exist; it is possible for human reasoning to understand such order in the universe as the process of natural creation and organization. The role of a transcendental existence is not certain. (Materialistic worldview).

#### **3.2. Metaphysical Concept**

In the inertial frame of reference, the principle of constant speed of light is a conceptual frame of dialectical metaphysics. Therefore, space time is not absolute. (Dialectical metaphysics)

From the belief that there is consistency due to order in the universe and that causality exists, and from the fact that the absolute time and absolute space of Newton which exists regardless of the observer does not match well with electromagnetism, Einstein inferred that in a inertial frame of reference assuming that the speed of light is absolute, that time and space are not independent. The faster an object moves relative to the observer, time passes at a slower rate, and the object shrinks more in the direction of movement. Only when this occurs can the speed of light remain constant. In addition, for objects of increasing speed, the inertial mass (rest mass) also increases. Mass and energy came to be considered equivalent concepts (Henry, 2012). The absolute and singular time created by God described by Newton, was changed to relative time of man according to the special theory of relativity.

Specific topics such as the simplicity of nature, and the symmetry of theories is used not only when a scientist evaluates a theory, but also provides important motivation during the process when they proceed researching with the belief of the validity of that scientific theory (Holton, 2000).

A clear characteristic of modern physics is that the concept of evolution has emerged from philosophy and infiltrated into all fields of physics. Omelyanovsky spoke as follows about modern physics (Gribanov, 1987): The new physics are as a rule an integrated science consisting of fundamental theories (the source of these are interrelated). In addition, these are in the form of a hierarchal helix structure that grows together with the development of human culture, technology, industry, and society as a whole. In modern physics, while experimental data is described using classical physics, their interpretation is made using non-classical theory (p.370).

#### **3.3.** The Influence of Kant

As empirical truth cannot be derived from definite perception (Hume), and as cognition is impossible without the common concepts of cause and effect, time, space, etc., Kant came to the conclusion that definite knowledge ultimately has independent from experience, universal, and inevitable a priori characteristics. This is because he attempted to dismiss Newton's metaphysical premises regarding time and space. However, Einstein not only accepted that aspect of Kant, but Einstein also accepted the fact that Kant not only aided in solving the dilemma faced by humans, but also the fact that perception itself through the senses cannot provide the required concepts on the essence of matter in the outside world. Using Kant's proposition, he argued against empiricists, who are those who argued that knowledge does not rely on mental activity but is gained directly from empirical data. He strongly maintained the idea that the world that surrounds us exists objectively separate from our perception (Gribanov, 1987).

#### **3.3.** The Influence of Dialectical Materialism

Einstein's thoughts fall under scientific concepts and principles, and his theories fall under history. As time passes, they need to be reevaluated and readjusted to fit reality. Opposite to the stance of Mach and Kant, Einstein argued that principles and categories have an objective characteristic, while at the same time when Mach presented his historical approach to classical mechanics it is not coincidence that Einstein thought highly of it (Gribanov, 1987). He introduced Kant's argument that our perception of nature exists through a metaphysical subjective conceptual frame. However, he did not approve the idea of the limitation of reason to understand matter itself, and Einstein did not accept the agnosticism that appeared in the spirit of Kant. Kant stated that it was fundamentally impossible to understand the essence of objects that exist in the outside world, and believed that if a phenomenon does not reflect objects then they fundamentally have no relationship with the object. However, Einstein started from the premise that the essence of matter could be perceived. What he was interested in was not the superficial properties of objects that appear externally, but the intrinsic characteristics of matter. However, these intrinsic characteristics are not provided to us directly through our senses. It is a subject that must be rationally abstracted and inferred from all the senses, that is the aggregate. These fundamental characteristics form scientific concepts (Gribanov, 1987).

It is establishing a conceptual system based on assumptions that are independent from and in opposition to each other. We have said that natural phenomena establish internal causal relationship between each other. This system expressly reveals the internal causal relationship between physics processes.

While classical physics derived all its laws from a single correct frame of reference which can be called the 'eye of God', the theory of relativity granted each observer an equal frame of reference. However, this does not mean that the theory of relativity has thrown Newton's theories into the trash heap of history. It merely expanded our field of vision to include the world of the extreme conditions of 'super speed' which Newton did not even imagine of. Therefore we can say that Einstein did not oust Newton but rather embraced Newton's world and expanded it.



With the discovery of differential calculus, in the stage of absolute space and absolute time, if we are provided with the speed of the change in distance or the speed for any point on a trajectory, we can define the acceleration which is the change in speed for that point. Through this Newton gained a differential equation that creates a relationship between force and acceleration (Newton's  $2^{nd}$  law). However, this equation is generally meaningless unless force is specifically given. The next step is the mathematical expression of gravity. By substituting the

expression on force derived from Newton's laws and Kepler's third law into the equation on the relationship between force and acceleration, we can solve this equation using the process of integral calculus. This research argued that successful theories which cohere with each other are approximately true, because of Special relativity of high level Coherence rather than Newton theory.

# **4.** Discussions and Conclusion

We can say that the theory of relativity is the change from Newton's metaphysical and mechanical worldview to Einstein's dialectical and historical worldview, and it is a new way of thinking which brought a revolutionary change to the mechanical worldview since Newton. The purpose of my study is to actively introduce Einstein's special theory of relativity which shows the theoretical coherence of the whole to show students and the public aesthetic aspects.

First, compared to the external consistent empirical exactness of Newtonian dynamics, Einstein's special theory of relativity increases the internal consistency which is an increase in the overall coherence between theories to show necessity. That is, it shows the aesthetic aspect of the theory through understanding. In addition, Park (2011) argued that successful theories which cohere with each other are approximately true, because of Special relativity of high level Coherence rather than Newton theory.

Second, while Newton derived all his laws from the single correct frame of reference from Kant's a priori intuition which has absolute and independent time and space, Einstein granted each observer with equal frames of reference. While Newton introduced the a priori metaphysical conceptual frame of a stage with an infinite and eternal God, Einstein's special theory of relativity includes Maxwell's electromagnetic theory, and with the conceptual frame that in a state of inertia the speed of light is constant, which is seen through experiments, he shows us a symmetry which gathers all the conflicting phenomenon creating a relative simplicity which is much more conceptually superior to Newtonian dynamics. It is a change from the mechanical worldview (applied in certain laws) based on a priori metaphysical premises (there is not qualitative change and only quantitative change is acknowledged), to a materialistic (maximization of human reason) worldview based on dialectical metaphysics (acknowledges qualitative change).

Forth, while Newton required absolute time and space where objects of a certain mass move, Einstein required relative space time which integrates conflicting theories to achieve symmetry. A comparison could be, before asking whether it is true that the surface of the earth is flat or round, the core of the problem becomes whether one should consider a geometric coordinate system appropriate for a front lawn or a coordinate system considering the whole world.

Finally, as the special theory of relativity is an area that is very difficult educationally, it is appropriate to use an approach utilizing thought experiments or comparisons which are relatively easier to comprehend. Above all, although Einstein published the special theory of relativity in 1905, it took considerable time for not only ordinary people but also scientists to accept the new worldview that was revealed through that theory. Therefore it is not surprising that this theory took a full 40 years to expand from the realm of physics to fully be incorporated as philosophy in the different realm of literary ideology. As such, to accept a new scientific theory entails a change in the philosophical realm of metaphysical faith, concepts, and value systems which correspond to conceptual schemes or conceptual frames. In this study, we proposed an understanding of the special theory of relativity based on the overall increase in coherence, and through a qualitative method of comparison and thought experiences as opposed to quantitative methods of the Lorentz transformation. This issue should be actively introduced in future education methods as a method of cyclical and self-reproducing education rather than the linear method of Euclidean geometry.

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