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ANALYSIS OF STUDENTS' CONCEPTIONS BASED ON COGNITIVE STYLE ON NEWTON'S LAW UNDERSTANDING

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ABSTRACT

Differences in students' cognitive style aspects allow for differences in students' conceptions of their understanding of Newton's laws. This study aims to determine the profile of students' conceptions in-depth based on their cognitive styles. This research used a qualitative method with a descriptive phenomenological design involving cognitive style tests with GEFT (Group Embedded Figured Test) on 30 students to be categorized based on their cognitive styles. From the 30 participants, three strongly field-dependent and three strongly field-independent students were selected. Six selected students were diagnosed using a four-tier diagnostic instrument for their understanding and conceptions. Semi-structured interviews were also conducted to investigate the students' conceptions in depth. This study concludes that field-independent (FI) students frequently display an inclination toward analytical thinking by self-exploring. However, they frequently experience difficulties in analyzing concepts without a solid foundation in physics, which can result in certain theoretical misconceptions. Conversely, field-dependent (FD) students can receive a broader range of information but demonstrate difficulties in analytical tasks, such as interpreting graphs and establishing causal relationships between physical quantities, which can result in correlational misconceptions. To rectify this misconception, it is imperative to implement a bespoke pedagogical strategy that integrates efficacious elucidations, tangible exemplifications, structured scaffolding, inquiry, and methodical practical exercises.

Keywords: cognitive style; misconceptions; Newton's law; student conceptions

INTRODUCTION

As an applicable branch of science, physics is very important to learn. Physics learning includes developing students' knowledge, understanding, and analytical skills regarding environments and surroundings (Azizah et al., 2015). However, physics is a complex subject; one of the materials is Newton's law. Newton's law is an essential aspect of physics and is the basis of classical physics. In line with Neidorf et al. (2020), the research results conducted in the last two decades in teaching physics show that misconceptions are a primary source of learning difficulties. Misconceptions about Newton's laws can have fatal consequences for the continuity of students' learning in the future. Newton's laws underlie all classical mechanics, such as dynamics (Goren & Galili,

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2019; Wati et al.,2023). Future learning will be disrupted if basic things like Newton's laws are misconceptions. Learning is an activity carried out by the teacher to give direction to students to have the correct understanding (Simplicio, 2000; Reilly et al., 2011; Fariyani et al., 2017; Widayanti et al., 2018). Not all students can understand concepts well during the learning process. In the construction of students' understanding of learning, cognitive biases are often employed that are perceived to be effective in life but are, in fact, scientifically problematic (Vosniadou, 2019; Hartelt & Martens, 2024). In fact, according to Martínez-Borreguero et al. (2024), it is essential to ensure coherence between the understanding of students and the scientific framework. The scientific method is epistemologically structured precisely, with a clear framework of thought that is consistently applied. In order to be considered valid, a scientific theory must be confirmed in both empirical and logical reality, as well as through a systematic methodology (Brock & Park, 2024). The study of physics necessitates that students undergo significant alterations in their methods of representing and elucidating the physical world and their reasoning processes (Vosniadou, 2019). Misconceptions about physics can arise from this. Modern learning, influenced by existentialist philosophy, posits that students construct their knowledge by paying attention to all aspects of science (Rumianowska, 2020; Schaffar & Wolff, 2024). Therefore, the teacher's attention to students must extend beyond the mere delivery of material to encompass an understanding of their individual needs.

According to findings of the last decade, students often misconstrue physics concepts (Guerra-Reyes et al., 2024; Listianingrum et al., 2024), and they frequently make mistakes when interpreting and comprehending a physics concept (Resbiantoro et al., 2022; Batlolona & Jamaludin, 2024). Understanding the relational structure of physics concepts and how they relate to each other is essential for students and teachers (White, 1993; Koponen & Nousiainen, 2013; Kõlamets et al., 2023). The concept will be meaningful if it contains information related to another concept. Students can get the concept in two ways: concept formation and concept assimilation (Kozhevnikov et al., 2014). Students can get idea formation before joining school, whereas concept absorption is achieved during and after school (Hanfstingl et al., 2022). Illusion discrepancy between students' understanding of concepts and actual concepts from experts is called misconceptions (Kalkanis et al., 2003; Mustaqim et al., 2014; Maulini et al., 2017; Kafiyani et al., 2019). Misconception is an error in connecting one concept with another, between a new concept and an old concept that already exists in the students' minds, so that a wrong concept is formed (Suprapto, 2020). Misconceptions in previous research occur due to various factors, including preconceptions, teachers, learning resources, learning methods, and students (Maharani et al., 2019). Many ontological studies have been conducted on misconceptions (Jauhariyah et al., 2018), showing that they harm learning outcomes because they prevent students from understanding the following concepts (Mustaqim et al., 2014; Maharani et al., 2019). Misunderstanding or misinterpreting information can impede learning and comprehension (Wancham et al., 2023).

For students, specific cognitive characteristics are different (Marinda, 2020). Cognitive style refers to persistent differences in how individuals organize and process information and experiences (Sholahuddin et al., 2021). Witkin & Goodenough (1981) proposed two cognitive elements: independent and dependent. Lu and Lin (2018) describe these two elements. Students with independent cognitive styles demonstrate independence in learning without being influenced by their environment and are active in the learning process, resulting in more broadly developed thinking patterns and various types of assumptions. While the dependent cognitive style depends on information obtained from the learning environment, individuals with this cognitive style are usually unable to criticize the data obtained and are passive in the learning process (Giancola et al., 2024).

Furthermore, these two types of cognitive styles have different behaviors in visual cognition (Zhu et al., 2022), critical thinking (Hasana et al., 2024), time-based prospective memory (Wang et al., 2024), and creativity (Harjono et al., 2024). Both sorts of cognitive styles contribute to the establishment of students' conceptions. Teachers can enhance students' understanding by considering their cognitive style. Students will learn more effectively when presented with information that aligns with their cognitive style (Margunayasa et al., 2019).

Understanding students' knowledge, or at least their perceived knowledge, allows educators to adapt their teaching methods to suit the needs of their students (Mustofa et al., 2024). According to researchers, misconceptions result in ineffective learning. Getting to know students better also has a positive impact on learning. With the awareness that misunderstandings can happen to everyone and awareness of differences in how to acquire and process knowledge can affect student conceptions. Previous research has revealed ontologically various causes of misconceptions. This study points to another side of the emergence of causes of misconceptions from students' cognitive styles to clarify that students' characteristics based on cognitive style can cause misconceptions in Newton's law, which can be a guide in determining learning strategies. (Ceuppens et al., 2018). As Dávila-Acedo (2017) posits, selecting teaching strategies and teachers' attitudes are the primary sources of students' happiness in learning, eclipsing the learning content. Furthermore, by understanding the influence of students' cognitive styles, their potential misconceptions can be identified and mapped by reviewing their cognitive styles.

METHODS

Research methods collect data with specific aims and applications (Sugiyono, 2008). This study used descriptive phenomenology qualitative analysis. This research design was used to explore and describe the generic experiences of participants (Shorey & Ng, 2022). Since sample size in phenomenology was determined by the quality and completeness of the information provided instead of the number of participants, this exploration in this study involved six students. Justification of participants chosen by three students with dominant FI (Field-Independent) cognitive style and three students with dominant FD (Field-Dependent) cognitive style from class 8 (12-14 years old) at junior high school in East Lombok, Indonesia, then given misconception tests and interviews.

Group Embedded Figured Test (GEFT) was adopted from the same test (Witkin, 1971) to determine students' cognitive categories. It was conducted on 30 students, and then three samples in the Strong Field Independent category and three other samples in the Strong Field Dependent category were selected. The GEFT instrument is a non-verbal test, and the test's psychometric properties are tested across cultures (Rassaei & Ravand, 2024). The GEFT is a standardized test with a fixed scale ranging from 0 to 18. Figure 1 illustrates an exemplar item from the GEFT instrument, wherein each correct response is assigned a value of 1, and each incorrect response is assigned a value of 0. This approach ensures greater objectivity in the assessment process.

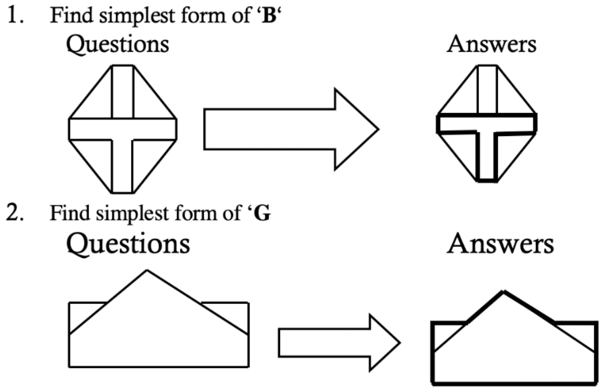


Figure 1. Group Embedded Figures Test (GEFT)

This categorization is interpreted by Witkin (1971) in Table 1. Table 1 shows students' cognitive styles based on their scores in answering questions on GEFT. In the context of this research, we only chose students with Strongly Field-Independent and Strongly Field-Dependent categories to give an actual depreciation on both cognitive styles. The selection of these two categories was made to facilitate a clear contrast in character between the two types of cognitive styles in terms of their misconception profiles. Witkin (1971) provides a detailed description of the cognitive styles category, accompanied by a score representation in Table 1. As illustrated in Table 1, individuals with scores within the slightly field-independent and slightly field-dependent categories might have shared characteristics.

Table 1. GEFT Representative Score

Category	Male Student Score	Female Student Score
Strongly Field Dependent	0 – 9	0 – 8
Slightly Field Dependent	10 – 12	9 – 11
Slightly Field Independent	13 – 15	12 – 14
Strongly Field Independent	16 – 18	15 – 18

(Witkin, 1971)

Based on six students who were determined to be given a misconception identification test using the Four-Tier Diagnostic instrument by Kaltakci-Gurel et al. (2017), which is a modification of the three-tier diagnostic instrument developed by Caleon & Subramaniam (2010). Initially, this instrument only provided questions and answers, the level of confidence in the answer, and the reasons for choosing the answer. The four-tier diagnostic adds a fourth level that asks for confidence in the reasons for choosing the answer.

This instrument consists of 20 questions developed using the revised Bloom taxonomy (Anderson et al., 2001), which covers Newton's laws. In order to ascertain the category of students' misconceptions, Table 3 provides details regarding the combination of four levels of answers that indicate the type of understanding to which the students in question adhere. After each student's misconception diagnosis data was obtained, a semi-structured interview was conducted to explore the reasons for the emergence of misconceptions.

Table 3. Combination of Answers of the Four Tier Diagnostic Test

Category	Answer	Confidence Level	Reason	Confidence Level
Misconception	Wrong	Certain	Wrong	Certain
Do not Understand Concept	Wrong	Certain	Wrong	Not Certain
	Wrong	Not Certain	Wrong	Certain
	Wrong	Not Certain	Wrong	Not Certain
Understand Concept	Correct	Certain	Correct	Certain
	Correct	Certain	Correct	Not Certain
	Correct	Not Certain	Correct	Certain
	Correct	Not Certain	Correct	Not Certain
Partially Understand Concept	Correct	Certain	Wrong	Certain
	Correct	Certain	Wrong	Not Certain
	Correct	Not Certain	Wrong	Certain
	Correct	Not Certain	Wrong	Not Certain
	Wrong	Certain	Correct	Certain
	Wrong	Certain	Correct	Not Certain
	Wrong	Not Certain	Correct	Certain
	Wrong	Not Certain	Correct	Not Certain
Error	If one, two, three, or all are not filled			

(Kaltakci-Gurel et al., 2017)

According to Tables 4 and 5, the research findings provide insights into the profiles of field independent students' conceptualizations of newton law of motions based on their learning experience. The criteria formulated by Amin et al. (2016) consist of 5 categories: misconceptions, do not understand concept, understand concept, and partially understand concept. Based on the data obtained from 30 students, six selected students were separated into two cognitive styles, field independent and field dependent, by mapping them using the Group Embedded Figured Test (GEFT), as shown in Table 4.

Table 4. Students in Strongly Field Dependent and Strongly Field Independent Cognitive Style

Participant	Gender	Score	Category
Student 6	Female	15	Strongly Field Independent
Student 9	Female	15	Strongly Field Independent
Student 11	Female	17	Strongly Field Independent
Student 2	Female	0	Strongly Field Dependent
Student 16	Male	1	Strongly Field Dependent
Student 20	Male	1	Strongly Field Dependent

Based on the grouping in Table 4, an assessment was carried out using the four-tier diagnostic test to determine the conception profile possessed by field-independent and field-dependent students. Both have differences that are pretty visible in how they solve problems based on their conception through interviews. From Table 5, in answering question 15 (see Figure 2), the FI subject wrongly answered the question with confidence but chose the correct explanation of the concept. In addition, the following shows interviews conducted with FI subjects.

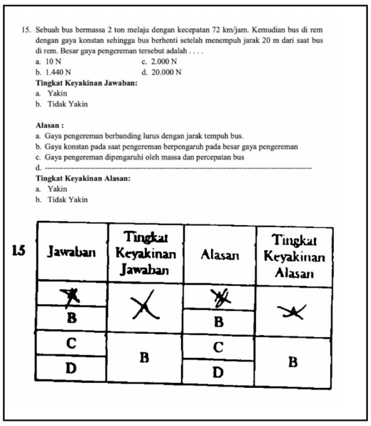
Table 5. Profile of Field Independent Students' Conceptions of Newton's Law

Participant	No. 4				No. 15			
	A	CL	R	CL	A	CL	R	CL
Student 6	C	V	W	V	W	V	C	V
Interpretation	Partially Understand Concept				Partially Understand Concept			
Student 9	W	V	W	V	W	V	W	V
Interpretation	Misconception				Misconception			
Student 11	W	V	W	V	W	V	W	V
Interpretation	Misconception				Misconception			

A: Answer
CL: Confidence level
R: Reason

C: Correct
W: Wrong
V: Certain
X: Not Certain

Below is the Figure 2. It shows the student answer to question number 15.



15. Sebuah bus bermassa 2 ton melaju dengan kecepatan 72 km/jam. Kemudian bus di rem dengan gaya konstan sehingga bus berhenti setelah menempuh jarak 20 m dari saat bus di rem. Besar gaya pengereman tersebut adalah . . . .

a. 10 N
b. 1.440 N
c. 2.000 N
d. 20.000 N

Tingkat Keyakinan Jawaban:
a. Yakin
b. Tidak Yakin

Alasan :
a. Gaya pengereman berbanding lurus dengan jarak tempuh bus.
b. Gaya konstan pada saat pengereman berpengaruh pada besar gaya pengereman
c. Gaya pengereman dipengaruhi oleh massa dan percepatan bus
d. --

Tingkat Keyakinan Alasan:
a. Yakin
b. Tidak Yakin

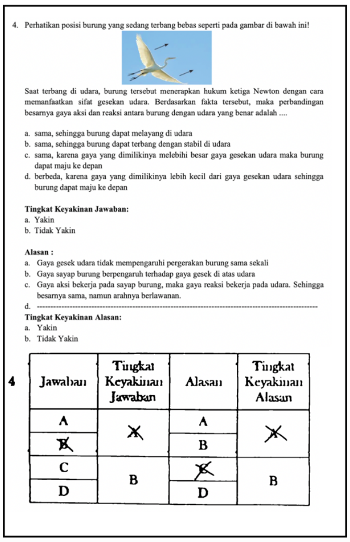
15	Jawaban	Tingkat Keyakinan Jawaban	Alasan	Tingkat Keyakinan Alasan
	[✓ A]	X	[✓ A]	X
	B		B	
	C	B	C	B
	D		D	

Figure 2. Student 9's Answers to Question Number 15

Interviewer: How do you calculate your answer?
Student 9: The distance per the mass, sir.
Interviewer: Which Newton's laws are related to this?
Student 9: Hmm, maybe the second, sir.
Interviewer: How does this problem relate to Newton's second law?
Student 9: Braking is the same as the distance traveled. So, the mass of the object matters.

The conversation between the interviewer and student 9 revealed a misunderstanding of Newton's Second Law. They assumed that braking depends on the distance inversely proportional to the mass. Braking is not inversely proportional to the mass.

In answering question 4 (see Figure 3), the FI subject wrongly answered the question with confidence but chose the correct explanation of the concept with confidence. In addition, the following are interviews conducted with FI subjects.



4. Perhatikan posisi burung yang sedang terbang bebas seperti pada gambar di bawah ini!

Saat terbang di udara, burung tersebut menerapkan hukum ketiga Newton dengan cara memanfaatkan sifat gesekan udara. Berdasarkan fakta tersebut, maka perbandingan besarnya gaya aksi dan reaksi antara burung dengan udara yang benar adalah ....

a. sama, sehingga burung dapat melayang di udara
b. sama, sehingga burung dapat terbang dengan stabil di udara
c. sama, karena gaya yang dimilikinya melebihi besar gaya gesekan udara maka burung dapat maju ke depan
d. berbeda, karena gaya yang dimilikinya lebih kecil dari gaya gesekan udara sehingga burung dapat maju ke depan

Tingkat Keyakinan Jawaban:
a. Yakin
b. Tidak Yakin

Alasan :
a. Gaya gesek udara tidak mempengaruhi pergerakan burung sama sekali
b. Gaya sayap burung berpengaruh terhadap gaya gesek di atas udara
c. Gaya aksi bekerja pada sayap burung, maka gaya reaksi bekerja pada udara. Sehingga besarnya sama, namun arahnya berlawanan.
d. --
Tingkat Keyakinan Alasan:
a. Yakin
b. Tidak Yakin

	Jawaban	Tingkat Keyakinan Jawaban	Alasan	Tingkat Keyakinan Alasan
4	A	[✓ A]	A	[✓ A]
	[✓ B]		B	
	C	B	[✓ C]	B
	D		D	

Figure 3. Student 11's Answers to Question Number 4

Interviewer: In your opinion, which of Newton's laws applies to this bird's wing?
Student 11: Newton's Third Law
Interviewer: From what point of view does Newton's Third Law apply?
Student 11: Wings and air friction. In force.
Interviewer: Is the style of both the same?
Student 11: It is different. The frictional force is more significant, so the bird's wing can lift and fly.
Interviewer: How about the direction?
Student 11: Opposite direction, sir.

In the conversation between the interviewer and student 6, there was a misconception regarding Newton's Third Law. Several explanations can be drawn based on the conversation regarding some students' misconceptions.

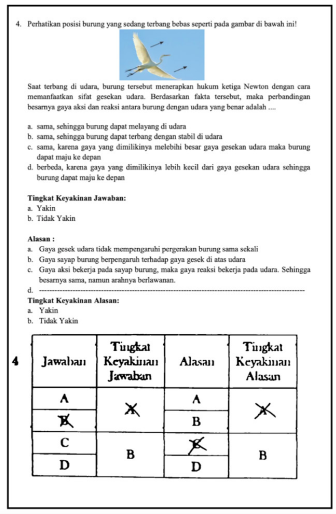
In answering question 1 (see Figure 4), FD subjects answered questions wrongly and explained concepts wrongly with confidence. In addition, the following excerpts from interviews with FD subjects.

Table 6. Profile of Field Dependent Students' Conceptions of Newton's Law

Participant	No. 1				No. 17			
	A	CL	R	CL	A	CL	R	CL
Student 2	C	V	C	V	W	X	W	X
Interpretation	Understand Concept				Do not Understand Concept			
Student 16	W	V	W	V	W	V	W	V
Interpretation	Misconception				Misconception			
Student 20	C	V	C	V	W	X	W	X
Interpretation	Understand Concept				Do not Understand Concept			

A:Answer	C: Correct
CL: Confidence level	W: Wrong
R: Reason	V: Certain
	X: Not Certain

Interviewer: In your opinion, what was Newton's Law asked in question 1?
Student 16: Hmm, the first.
Interviewer: Where do you conclude it from
Student 16: Inertia.
Interviewer: What are the characteristics of the chart?
Student 16: The line is going down.
Interviewer: So, how fast is the car?
Student 16: It is slowing down.



4. Perhatikan posisi burung yang sedang terbang bebas seperti pada gambar di bawah ini!

Saat terbang di udara, burung tersebut menerapkan hukum ketiga Newton dengan cara memanfaatkan sifat gesekan udara. Berdasarkan fakta tersebut, maka perbandingan besarnya gaya aksi dan reaksi antara burung dengan udara yang benar adalah ....

a. sama, sehingga burung dapat melayang di udara
b. sama, sehingga burung dapat terbang dengan stabil di udara
c. sama, karena gaya yang dimilikinya melebihi besar gaya gesekan udara maka burung dapat maju ke depan
d. berbeda, karena gaya yang dimilikinya lebih kecil dari gaya gesekan udara sehingga burung dapat maju ke depan

Tingkat Keyakinan Jawaban:
a. Yakin
b. Tidak Yakin

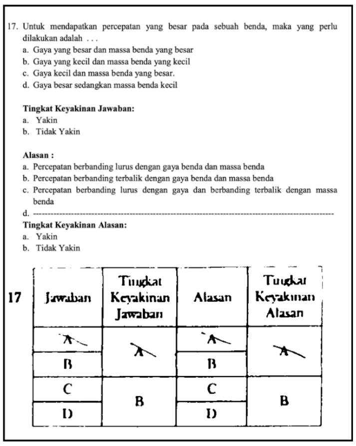
Alasan :
a. Gaya gesek udara tidak mempengaruhi pergerakan burung sama sekali
b. Gaya sayap burung berpengaruh terhadap gaya gesek di atas udara
c. Gaya aksi bekerja pada sayap burung, maka gaya reaksi bekerja pada udara. Sehingga besarnya sama, namun arahnya berlawanan.
d. --
Tingkat Keyakinan Alasan:
a. Yakin
b. Tidak Yakin

4	Jawaban	Tingkat Keyakinan Jawaban	Alasan	Tingkat Keyakinan Alasan
	A	[✓ A]	A	[✓ A]
	[✓ B]		B	
	C	B	[✓ C]	B
	D		D	

Figure 4. Student 16's Answers to Question Number 1

The conversation between the interviewer and the FD subject revealed a misconception related to Newton's First Law. The student can confidently explain that the event was inertia but was wrong in analyzing the graph. He stated that the downward graph is a form of inertia. Inertia is a state where an object maintains its condition while maintaining its speed in this context.

Furthermore, the same student also experienced misconceptions about Newton's Second Law on question 17, as shown in Figure 5.



17. Untuk mendapatkan percepatan yang besar pada sebuah benda, maka yang perlu dilakukan adalah . . .
a. Gaya yang besar dan massa benda yang besar
b. Gaya yang kecil dan massa benda yang kecil
c. Gaya kecil dan massa benda yang besar.
d. Gaya besar sedangkan massa benda kecil

Tingkat Keyakinan Jawaban:
a. Yakin
b. Tidak Yakin

Alasan :
a. Percepatan berbanding lurus dengan gaya benda dan massa benda
b. Percepatan berbanding terbalik dengan gaya benda dan massa benda
c. Percepatan berbanding lurus dengan gaya dan berbanding terbalik dengan massa benda
d. --
Tingkat Keyakinan Alasan:
a. Yakin
b. Tidak Yakin

17	Jawaban	Tingkat Keyakinan Jawaban	Alasan	Tingkat Keyakinan Alasan
	[✓ A]	[✓ A]	[✓ A]	[✓ A]
	B		B	
	C	B	C	B
	D		D	

Figure 5. Student 16's Answers to Question Number 17

Interviewer: What is needed to get a significant acceleration on an object?
Student 16: We must apply a large force and have a large object mass.
Interviewer: Why do you think so?
Student 16: Newton's law says that acceleration is directly proportional to the force exerted on an object and inversely proportional to the object's mass. So, if we want a significant acceleration, we must apply a large force and have a large object mass.

The conversation between the interviewer and student 16 revealed a misconception about Newton's Second Law. He stated that increasing acceleration requires force, and a large object where a large mass should be inversely proportional to acceleration.

Witkin (1971) and Witkin et al. (1977) proposed a classification of cognitive styles, delineating two primary categories: field-dependent (FD) and field-independent (FI). As mentioned earlier, the grouping of intellectual cognitive styles posits that both groups of cognitive styles exhibit a proclivity toward acquiring and processing knowledge. It aligns with the cognitivist theory, which posits a similar assertion. In cognitivism, acquiring, organizing, storing, and retrieving knowledge is an internal mental activity. Students' cognitive processes in learning will entail the processes of assimilation and accommodation. Knowledge assimilation occurs when an individual encounters new information consistent with their cognitive framework. This integration facilitates the organization of new information within their cognitive structure, thereby maintaining equilibrium. In physics, as a discipline integrated into the everyday environment of students who adhere to a specific cognitive schema, the content of physics lessons in an educational setting may or may not align with their underlying cognitive structure.

In this study, we examine students' conceptions of Newton's law because it represents one of the most foundational topics in physics. Most classical mechanics are predicated upon Newton's laws of motion (Isra & Mufit, 2023). It will be a problem that will continue if the basic schemes that students build do not experience appropriate assimilation and accommodation; disorientation in understanding physics in the future is very likely to occur. Based on Table 4 on questions 4 and 15, almost all students categorized as strongly field independent do not have a complete conception. Then, in Table 5, on questions 1 and 17, Student 16 experienced misconceptions.

Based on Table 5 and the semi-structured interview, student 9 (FI) stated that the way to calculate braking events is "distance to mass." However, this is an erroneous statement. Newton's Second Law discusses force, acceleration, and mass, not "distance to mass." The correct calculation is where F is the force, m is the mass, and x is the distance. This misconception may arise because students need to understand the concept of distance and force calculations. The student initially thought this problem was related to Newton's second law but then doubted it and said it might be related to Newton's Second Law. It indicates a misconception related to identifying relevant laws in the context of the problem. The student associates braking with the distance traveled and the object's mass. However, this needs to be better understood. Newton's Second Law deals with the relationship between force, mass, and acceleration. Mileage is usually more related to the kinematics concept than Newton's Second Law. The conversation illustrates a misconception about understanding Newton's Second Law. These misconceptions include errors in force calculations, unclear identification of relevant laws, and a jumble of concepts such as distance, mass, and braking. Such misconceptions must be addressed through better teaching approaches, including providing clear and repeatable explanations, concrete examples, and appropriate exercises to help students understand these concepts in greater depth.

The misconceptions experienced by the ninth student are classified as theoretical and correlational misconceptions (Fuat et al., 2020; Istinabila & Fardah, 2022). Theoretical misconceptions are a form of misconception based on errors in studying facts or events in an organized system and errors in connecting concepts between one quantity and another in physics. This student is classified as a student with an FI cognitive style based on the statement from Agoestanto et al. (2019). Students with FI cognitive style tend to make mistakes at the understanding, transformation, and process skills stages. The cause, according to Agoestanto et al. (2019), is a lack of understanding related to mathematical modeling of errors in correlating the relationship between force and distance because to find out the relationship between force and distance, there needs to be a mathematical derivation of the fundamental equation which changes the acceleration in the form of its second derivative (Giancoli, 2022).

In the subsequent discussion, student 6, as FI cognitive style, posited that Newton's third law is applicable between bird wings and air friction. However, this assertion requires further clarification. Newton's third law pertains to the interaction between two dissimilar bodies, not between objects and forces acting upon them. The air friction force on a bird's wing cannot be equated with the force acting on the wing itself. The student said that air friction is greater than the force of the bird's wings; therefore, the bird can lift and fly based on his thinking. However, this is also a misconception. Newton's third law states that the magnitude of the force of action and reaction is the same. According to this law, if a bird's wing exerts a downward force (action force), the air exerts an upward force (reaction force) of the same magnitude. These forces must be balanced for the bird to stay balanced or fly. The student says that the directions of the action and reaction forces are opposite (Giancoli, 2022). This is a correct concept according to Newton's third law. However, due to a misunderstanding of the magnitude of the force of action and reaction, this misconception further obscures their understanding of the concept as a whole.

The conversation indicates some common misconceptions among students regarding Newton's Third Law (Isra & Mufit, 2023). It is also a theoretical and correlational misconception based on Fuat et al. 2020 and Istinabila & Fardah (2022). These misconceptions include a wrong understanding of how this law applies to the frictional forces of air and bird wings, the magnitude of the action and reaction forces, and how the directions of the action and reaction forces are related. As frictional force with air and force is considered an abstract concept, Giancola et al. (2022) and Li et al. (2023) state that FI students have more potential to understand abstract concepts better than FD students. Therefore, educators must identify and overcome these misconceptions by providing students with correct and in-depth explanations about this physics concept. Witkin (1971) states that those who analyze themselves without involving their environments cannot do checks and balances. So, the role of teachers is to guide and strengthen students' analytical abilities through various appropriate teaching methods, such as implementing conflict cognitive. Santia (2015) suggests that students with this character should be given freedom as a suitable method so that inquiry-based learning might suit them.

Based on Table 5 and semi-structured interviews, student 16 experienced misconceptions about inertia. The student stated that Newton's first law (Law of Inertia) relates to a slowing speed, which is incorrect. Newton's First Law talks about objects that will remain stationary or in uniform, straight motion unless a force is acting on the object (Giancoli, 2022). This student's statement needs to show a better understanding of this legal concept.

The student misinterpreted the graph. He said that the line that descends on the graph shows the characteristics of Newton's first law with a high self-confidence. The corresponding line on the graph related to Newton's First Law is straight. This also indicates a need to clarify the concept of velocity and velocity change. The conversation reveals some common misconceptions among students in the context of Newton's First Law. These misconceptions considered Classification Conceptual Misconceptions (Fuat et al., 2020), including incorrect identification of laws, misinterpretation of the concepts of speed and deceleration, and the relationship between laws and movement charts. The high self-confidence displayed by student 16, as evidenced by Ghufron & Suminta (2020) and Sutama et al. (2021), indicates that FD students tend to have high self-confidence but do not engage in cross-checks. This trait has the potential to produce erroneous conceptions, as evidenced by Anwar et al. (2020), who found that FD students have difficulty understanding graphs. Per Agoestanto et al. (2019), the student in question demonstrated an inability to code the concept of inertia in graphical form correctly. Therefore, educators must detect this misconception and give students a more precise and in-depth explanation of this physics concept.

In question number 17, student 16 stated that to get a significant acceleration, it is necessary to apply a large force and have a large object mass. This is a standard view but wrong. Newton's Second Law states that acceleration is directly proportional to the force exerted on an object and inversely proportional to the object's mass (Giancoli, 2022). However, this student's view of encapsulating these two factors into a single whole deviates from the principles of the law. This misconception is included in the Correlational Conceptual Misconception (Fuat et al., 2020).

This conversation highlights a common misconception related to Newton's Second Law. The student believed that acceleration can only be obtained by applying a large force and having a large object mass, even though the concept is more complicated. More precisely, Newton's Second Law states that if the force exerted on an object remains constant, the acceleration will be more significant if the object's mass is more minor. The acceleration will be smaller if the object's mass is more significant. This misconception can arise because of the wrong interpretation of how force and mass affect acceleration. Ubuz & Aydınyer (2019) have observed that FD students exhibit deficiencies in their critical thinking skills, particularly in the interpretation and analysis stages.

Most of the misconceptions appear in Newton's second law. This follows Kaniawati et al. (2019) and Temiz & Yavuz (2014), who found that errors in understanding Newton's second law often occurred. Educators must provide a clear and in-depth explanation of Newton's Second Law in this context. Educators can simplify abstract problems into concrete ones in everyday life and use concrete examples, experiments, or situations in everyday life to help students understand this concept better and overcome any misconceptions that may arise (Dita et al., 2021; Muhamad et al., 2021). Santia (2015) also explained that because FD students tend to be able to obtain such extensive information and are so easily influenced by their environment, appropriate assistance/scaffolding is needed. This is in accordance with our findings that what influences students' misconceptions is external experiences that students misinterpret and misunderstand.

CONCLUSION

This study concludes that field-independent (FI) students frequently display an inclination toward analytical thinking by self-exploring. However, they frequently experience difficulties in analyzing concepts without a solid foundation in physics, which can result in certain theoretical misconceptions. Conversely, field-dependent (FD) students can receive a broader range of information but demonstrate difficulties in analytical tasks, such as interpreting graphs and establishing causal relationships between physical quantities, which can result in correlational misconceptions. To rectify this misconception, it is imperative to implement a bespoke pedagogical strategy that integrates efficacious elucidations, tangible exemplifications, structured scaffolding, inquiry, and methodical practical exercises.

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