EXPLORING EPISTEMIC COGNITION IN DIFFERENT TASK CONTEXTS

by

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ABSTRACT

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In this study epistemic performance in different task contexts was studied. There were, 2 physics professors, 4 teaching physics undergraduate students and 4 social sciences undergraduate students. Apt-AIR framework was adopted as the analytical framework. Data were collected using think aloud protocol and semi-structured interviews. In data analysis, (a) various examples for cognitive elements of epistemic performance were identified, (b) various behaviours related to metacognitive elements of epistemic performance were encountered and (c) comparisons were made between groups' epistemic performances. The first task context was related with physics. Physicists have demonstrated a wide range of cognitive and metacognitive elements of epistemic performance. By doing so they have helped us to paint a picture of disciplinary characteristics of physics. All groups have identified experimentation and observations as reliable processes for producing or evaluating a knowledge claim. The theme of the second task context was mandatory covid vaccine. While evaluating knowledge claims and choosing sides, physicists have looked for the data. They have argued there were adequate amount of data during the time the video was shot. Teaching physics students, mostly trusted to their personal experiences and emotions. The frequency of demonstrated metacognitive elements of epistemic performance was lowest among teaching physics students compared to other two groups. The third group, social sciences students have kept well-being of the society at front while engaging with the second issue. The findings of the study tells us epistemic performance is contextual and Apt-AIR framework works as an analytical framework while capturing the cognitive and metacognitive elements of epistemic performance. The results suggest, there is a need to develop pre service teachers' ability to perform apt epistemic performance.

ÖZET

FARKLI GÖREV BAĞLAMLARINDA EPİSTEMİK BİLİŞİN KEŞFEDİLMESİ

Bu çalışmada farklı görev bağlamlarında epistemik performans incelenmiştir. 2 fizik profesörü, 4 fizik öğretmenliği lisans öğrencisi ve 4 sosyal bilimler lisans öğrencisi vardır. Analitik çerçeve olarak Apt-AIR çerçevesi benimsenmiştir. Veriler, sesli düşünme protokolü ve yarı yapılandırılmış görüşmeler kullanılarak toplanmıştır. Veri analizinde (a) epistemik performansın bilişsel unsurlarına yönelik çeşitli örnekler belirlenmiş, (b) epistemik performansın üstbilişsel unsurlarına ilişkin çeşitli davranışlarla karşılaşılmış ve (c) grupların epistemik performansları arasında karşılaştırmalar yapılmıştır. İlk görev bağlamı fizikle ilgilidir. Fizikçiler, epistemik performansın çok çeşitli bilişsel ve üstbilişsel unsurlarını gösterdiler. Bunu yaparak, fiziğin disipliner özelliklerinin bir resmini çizmemize yardımcı oldular. Tüm gruplar deney ve gözlemi bir bilgi iddiasını üretmek veya değerlendirmek için güvenilir süreçler olarak tanımlamıştır. İkinci görev bağlamının teması zorunlu covid aşısıydı. Fizikçiler bilgi iddialarını değerlendirirken ve taraf seçerken verileri baktılar. Videonun çekildiği sırada yeterli miktarda veri olduğunu iddia ettiler. Fizik öğretmenliği öğrencileri ise çoğunlukla kişisel deneyimlerine ve duygularına güvendiler. Epistemik performansın gösterilen üstbilişsel unsurlarının sıklığı, diğer iki gruba kıyasla fizik öğretmenliği öğrencileri arasında en düşüktü. Üçüncü grup olan sosyal bilimler öğrencileri, ikinci konu ile ilgilenirken toplumun refahını ön planda tutmuşlardır. Çalışmanın bulguları bize epistemik performansın bağlamsal olduğunu ve Apt-AIR çerçevesinin epistemik performansın bilişsel ve üstbilişsel unsurlarını yakalarken analitik bir çerçeve olarak çalıştığını söylüyor. Çalışmanın sonuçları, öğretmen adaylarının uygun epistemik performans sergileme becerilerinin geliştirilmesine ihtiyaç olduğunu göstermektedir.

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1. INTRODUCTION

In today's world where false news and misinformation are very common, a citizen must be able to evaluate knowledge to make informed and well justified decisions (Chinn *et al.*, 2021). These decisions can be about personal healthcare or society. For instance, during COVID19 pandemic there were lots of conflict regarding how to fight with the disease both as a society and as an individual. To make an adequately well justified decision regarding this matter, one must utilize fields such as epidemiology, sociology and economics (Green *et al.*, 2021). Another example is constructing hydroelectric power stations for producing electricity. There are contradictory views about its economic benefits and potential harms to the environment (Elden & Öztürk, 2020). To reach a well-grounded conclusion in such matters, a citizen must demonstrate apt epistemic performance. Epistemic performance can be defined as achieving epistemic aims. Reaching a conclusion, evaluating a knowledge claim, producing a knowledge claim can be given as examples to epistemic aims. There are cognitive and metacognitive elements of epistemic performance. Choosing appropriate combinations of cognitive and metacognitive elements which result in reliable knowledge process or sound decisions can be defined as an expert like epistemic performance. In other words, if the set epistemic aims are valuable and if these aims are achieved through competence, then the epistemic performance can be identified as apt (Barzilai & Zohar, 2016). Developing the ability of performing apt epistemic performance might require being an expert in a particular field. However, a person may master one or two discipline/s in her/his lifetime. Hence, when an expert encounters such cases, if the case is related to a discipline where s/he does not have any expertise, then s/he needs to adapt her/his expertise of evaluating knowledge claims to a different discipline. Then, understanding how people transfer and adapt their epistemic performance between different contexts is an important question to study.

1.1. Statement of the Problem

From the second half of the 19th century until today, there have been many studies focusing on the relationship between epistemology and different aspects of education. In those studies, different analytical frameworks have been used. One of those frameworks is Apt-AIR framework. Apt-AIR framework was presented by Barzilai and Chinn (2018), to describe cognitive and metacognitive elements of epistemic performance. The framework is relatively new compared to other frameworks built for conceptualizing epistemic performance. It fills several gaps where other frameworks have failed. At the later parts of this review, those gaps and how Apt-AIR framework fills them are presented. The only empirical investigation of the framework has been done in a research study conducted by Greene *et al.*, (2021). In the same study, the researchers also studied how ability to demonstrate apt epistemic performance regarding a particular discipline can be transferred to a different one. That study was conducted with social and natural scientists.

Considering the importance of the ability, investigating whether preservice teachers possess the ability of demonstrating apt epistemic performance and transferring this expertise from one discipline to another, is plausible. Because they will be the teachers who will raise the new generations. In parallel with this idea, teaching physics students are included in the study.

The researchers explored epistemic performance within the context of two different issues. The first of those issues was focusing whether the universe is fine tuned or not. Physics professors were included in the study. It was expected from them to set an example for apt epistemic performance regarding the first issue. Teaching physics students are included as well, because they will raise the new generations. Hence, it is important to explore how apt they in their prospective field. Teaching physics students receive an education focusing on physics. On the other hand, social sciences students receive an education focusing on social sciences. In the expectation of seeing differences among cognitive and metacognitive elements of epistemic performance based on

different focuses of received education, social sciences students were included in the study as well.

The focus of the second issue included in the study, was mandatory covid vaccine. Because of its focus the issued concerned the whole society. All of the participants have provided examples of cognitive and metacognitive elements of epistemic performance within the context of the second issue. Lastly, a comparison of how each groups' approach to the issues have differed has been made. Studying the comparison was important. Because as stated earlier, transferring expertise in performing apt epistemic performance between contexts is a requirement in today's society.

1.2. Significance of the Study

To my knowledge there are no studies which investigated preservice teachers' epistemic performance. Also coronavirus pandemic relatively recent event. Hence, it is plausible to study how people choose a side in an issue related with the pandemic. In the study of Greene *et al.*, (2021), the context was provided to the participants through texts. However, today YouTube is one of the most visited websites in the world. It has been visited more frequently in any other news website which presents information or argument in the form of a text. Hence, considering this change of trend of how people follow discussions or latest news, videos from YouTube were preferred as materials. In the studies related with epistemic performance, in my knowledge, there were no attempt to take a picture of nature of physics through the eyes of physicists. In that regard, the study is unique. Another uniqueness of the study is that it takes place in Turkey.

1.3. Purpose of the Study and Research Questions

Hence, in parallel with those ideas, I propose a research study which investigates epistemic performance of physicists, preservice physics teachers and social sciences students through cognitive and metacognitive elements in different task contexts. Ac-

cordingly, my research questions are:

(i) What are the cognitive and metacognitive elements of epistemic performance demonstrated by physics professors (physicists) when engaging in a controversial physics issue and a socio scientific issue?

(ii) What are the cognitive and metacognitive elements of epistemic performance demonstrated by teaching physics students when engaging in a controversial physics issue and a socio scientific issue?

(iii) What are the cognitive and metacognitive elements of epistemic performance demonstrated by social sciences students when engaging in a controversial physics issue and a socio scientific issue?

(iv) What are the similarities and differences between cognitive and metacognitive elements of epistemic performances demonstrated by teaching physics students, physics professors and social sciences students while engaging a controversial physics issue and a socio-scientific issue?

2. LITERATURE REVIEW

In this review, how epistemology is studied within educational research context and which models were used while conducting those studies are presented. Later a discussion is made regarding the contributions and problems of these models. The review continues with introducing Apt-AIR framework and describing how the transfer of apt epistemic performance can be modeled. At the end of this review, considering the gap in the literature, research questions are proposed.

2.1. Stage Like Theories and Epistemological Beliefs

The early conceptualizations of epistemic cognition consisted of stage like theories following the developmental tradition of Piaget (Hofer & Pintrich, 1997) and epistemological beliefs.

2.1.1. Forms of Ethical and Intellectual Development

Epistemology is a branch of philosophy which studies knowledge. The word epistemology can be translated as "theory of knowledge" (Greene *et al.*, 2016). The idea of adopting the views on epistemology from philosophy in education is not new. The field of epistemology started to enter the radar of the educational psychologists with the work of William Perry (1970). Since then, epistemology in education adopted different names and different constructs. Research on epistemology in education begins with stage like theories. Perry (1970) and his team investigated intellectual and ethical development of undergraduate students by conducting interviews with them through their college years. The analysis of the interviews revealed a pattern in the perceptions of the students regarding knowledge. The elements of knowledge consisted of structure of knowledge, source of knowledge and tentativeness of knowledge. Perry and his team reflected on those elements, and they defined positions by reviewing students' views on knowledge, the role of the instructor, the role of the student, the role of the peers in

the learning process, evaluation issues, primary intellectual tasks, sources of challenge and sources of support. There was an order of appearance among positions. Perry preferred to use word "position", instead of "stage" for three reasons. First, there was no assumption in the framework regarding for how long a person stays at a particular stage. Second, a student might demonstrate more than one stage over time. However, the word "position" thought to reflect a central tendency. Lastly, the word "position" found to be more convenient to explain how a person views her/his world than the word "stage". In the study, nine positions were detected. Those positions were: (1) basic dualism, (2) multiplicity pre-legitimate, (3) multiplicity subordinate, (4) multiplicity correlate or relativism subordinate, (5) relativism correlate competing or diffuse, (6) commitment foreseen, (7) initial commitment, (8) orientation in implications of commitment, (9) developing commitment/s.

Basic dualism was labeled as simplest position in terms of views on nature of knowledge and values by Perry. People in this position viewed knowledge as a collection of absolute rights and wrongs. In terms of the role of the authority, they assumed what an authority says as right without questioning. Basic dualists viewed the role of the student as to obedient to the authority. In the context of college, this authority was professors. Outside sources of knowledge, such peers, were seen as sources of wrongs. They also viewed their professors as main sources of support. They have not developed the ability to evaluate. Because during the study, students in this positions have not used words such as "better" or "worse". They viewed recalling facts as a primary intellectual task. Basic dualists made up a very small portion of participants of Perry's research. A professor who asks students to critically think, culturally diverse environment in dorms or becoming aware of authority who know and authority who doesn't know caused basic dualist to advance their positions. Perry detected very few examples of basic dualists.

In multiplicity pre-legitimate position, students acknowledged the existence of questions where there can be more than one right answer. They became familiar with such questions in social sciences courses. Encountering with these questions made

students agitated and such questions were perceived as challenges. Multiplicity pre-legitimatists thought spending time solving them was a waste of time. Hence, they felt anger towards their professors. Because the professors were the ones who made the students engage in such problems. However, the authorities (professors) were still perceived as legitimate and only sources of knowledge. In that regard, multiplicity pre-legitimate position is similar to the position of basic dualism. Students thought, natural sciences and mathematics were a safe heaven. Because courses of that disciplines emphasized procedural knowledge at the freshman and sophomore years. Even though, the students in this position becomes acquainted with pluralism, there was no sign of evaluation.

In multiplicity subordinate position, evaluation criteria came to exist. This happened when students started to question the evaluation criteria which their professors used while grading homework or exams. Other aspects of this position reflected the qualities of multiplicity pre-legitimate position.

There are two options in the fourth position: multiplicity correlate or relativism subordinate. In multiplicity correlate the students believed in right-wrong in other words dualism. However, in some areas they thought that absolutism may be doubted. They perceived that there are two domains. The first domain is the domain of authority which is fundamentally dualist (according to the students) and there is the domain of the self where absolutism can be doubted. Hence, to some point, students who belonged to multiplicity correlate position still accommodated features of basic dualism. This position was thought to be significant by Perry. Because in this position, in the second domain an actualisation of the self begins. In relativism subordinate, multiplicity does not exist as a separate domain. Multiplicity is in the domain of the authority. The students who are relativism subordinate acknowledges the ideas related to relativism such as “more than one factor” and “existence of multiple approaches while solving a problem”. However, these acknowledgments occurred not intrinsically. The students acknowledged them because their professors wanted. Hence, they found multiplicity as chaotic and perceived relativism as a specific way of thinking for certain type of

problems. So, the students continued to keep their dualistic beliefs regarding knowledge. In summary, there were specific cases (such as complexities within an economic or historic event) where their instructors wanted them to think about by considering multiplicity, and there were other cases where there are absolute rights and wrongs. Hence the concept of dualism and multiplicity coexisted in this position. According to Perry, relativism subordinate was the most common path which students followed.

In position five (relativism correlate competing or diffuse), Perry observed the idea of relativism developed intrinsically, independently from the authority. This was firstly observed in this position. In the fourth position, ideas related multiplicity and relativism were perceived to be valid for specific cases. However, in fifth position, it was the opposite. The students perceived relativism to be a common property of all thought. The ideas about absolute rights and wrongs were perceived to be valid for specific cases. Newtonian mechanics was considered to be one of them. The role of professors changes in this position as well. Previously, the professors were believed to be sources of absolute truths. However, in this position they were perceived as people who were experienced in handling uncertainties related to their field of study. People at position five thought the validity of knowledge is determined the constraints of the context. In position five, relativism was adopted by not making any personal choice or commitments.

The sixth position is called commitment foreseen. In his study, Perry defines commitments as affirmations which are made by individuals by coming terms with their pasts. Commitments can be made about general values, endeavours, politics, social, friendships, religion, marriage and career. Commitments are made in a relativistic world. Hence, commitments made without evaluation and reasoning is multiplicity. In the position six, even though students acknowledged the necessity of making commitments, they have always used future tense while talking about their own commitments. This is why this position is called commitment foreseen.

Seventh, eighth and ninth positions were presented by Perry under the same essay. He argued there was no significant reconstruction of background of life. In these positions, the development only happens in terms of one's own commitment. Hence, a person's views on role of the instructor and structure of knowledge are the same as a person's who are in position five, views. In position seven, person finally makes a commitment (for instance deciding on the major which s/he would like to study). However, those commitments don't settle easily. Because they are always affected by the external factors. This situation leads students to move forward to position eight. In this position, students start to question the effects of external factors on one's commitments. For instance, a student who made a commitment by choosing studying medicine reflects the behaviour of a position seven person. However, if the student starts to ask questions such as "how many ways are there to study medicine", this means that s/he moved forward to position eight. In the final position, person accepts that commitments shaped according to external factors. As a result, the person gains the ability to identify what s/he can do and what s/he can not do. Significant number of them were not able to reach the final position at the end of their college education.

Perry's framework is a synchronous one, one cannot skip positions while developing. In that regard, it is similar to Piaget's theory of cognitive development (Hofer & Pintrich, 1997). Even though he did not use the word "stage", the theoretical framework possessed the properties of stage like theories.

2.1.2. Woman's Way of Knowing

Perry's work has shed some light on the phases which individual go through during their time in a liberal arts college. But there was some heavy criticism because the sample only included upper middle class white males. In order to fill the gap in the literature, Belenky *et al.*, (1986) conducted a similar study to Perry's. The sample only included females who had diverse backgrounds. As the data collection method, the authors used interviews. The questions asked in the interviews were similar to the Perry's questions. They too presented a synchronous development stage theory for epistemo-

logical development. Each stage was called way of knowing. The aim of the study was to present "the voice of the women". Belenky *et al.*, 's research suggested the following ways of knowing: (1) silence, (2) received knowledge, (3) subjective knowledge, (4) procedural knowledge, (5) constructed knowledge. Those epistemological perspectives are identical to the stages suggested by William Perry, except silence.

The women in the silence epistemological perspective, demonstrated no voice. When they are asked a question, whether it is simple or not, they responded with the phrase "I don't know. I have to ask my husband". Sometimes the word husband can be replaced by father or any other male authority figure in the women's life. Most of the women who were in that stage had a history of physical and psychological abuse. The authors argue that this the reason why those women develop that way of knowing. Received knowledge was similar to Perry's position of dualism. Unlike silence, the women in this stage can talk about the knowledge, even though it originates externally. In their research, Belenky *et al.*, used subjective knowledge interchangeable with Perry's multiplicity. The women in this stage, believed in equality of views. The women in the procedural knowledge stage demonstrated reasoning and systemic analysis. Hence, procedural knowledge reflected the properties of Perry's relativism stage. Belenky *et al.*, realised procedural knowledge can take two forms; separate knowing and connected knowing. She called those forms epistemological orientations. In that regard, it was different from Perry's theory. Separate knowing emphasised the role of critical thinking in the process of knowing. Connected knowing on the other hand, emphasised the importance empathy. Hence, the women who have demonstrated epistemological orientation of connected knowing valued understanding over judgment. Belenky *et al.*, argued that this difference is possibly gender related. Last and most advanced stage was constructed knowledge. Women at this stage believed knowledge and truth are contextual. Furthermore, they thought that all knowledge and one's form of reference are constructed by the knower.

Unlike Perry's research, Belenky *et al.*'s research's focus was outside of the education context. The examples or experiences presented by the participants were from

their lives outside of the school. However, the study shed light on the effects of suppression on the epistemological development. Another difference was the focuses of each theory. Perry's theory emphasized nature of knowledge and truth. Belenky, on the other hand, emphasized the source of knowledge and truth.

2.1.3. Argumentative Reasoning

Another significant stage like theory was introduced by Deanna Kuhn (1991). In her study, Kuhn focused on the relationship between epistemologies and how people reasoned while engaging in ill-structured problems from daily life. Those problems were (a) what causes prisoners to return to crime after they're released?, (b) what causes children to fail in school?, and (c) what causes unemployment? The common point of those problems was that they all lacked a definitive solution. The participants were asked to justify their positions by using evidence and produce a remedy to each problem. The last part of the interview, focused on participants' epistemological reflections on their reasonings. At the end of the study, she was able to distinguish three types of epistemological views which were similar to the Perry's framework. Those views were (1) absolutist, (2) multiplist and (3) evaluatist (Hofer & Pintrich, 1997).

Absolutists regarded knowledge as certain and absolute. Also they were very certain about their own beliefs. In that regard, they were similar to dualists from Perry's study. Multiplists believed in absolute subjectivity. They thought one's view can be equally valid as of an expert's view. Hence, unlike absolutist, they rejected the idea of absolute and certain knowledge. However, their idea of absolute subjectivity, caused them to value ideas and emotions over facts. Evaluatists, like multiplists, denied the existence of absolute and certain knowledge. However, they thought their views were not equally valid than experts'. According to evaluatists, the validness of a view can be compared and evaluated by using facts. Hence, unlike multiplists, evaluatists believed that some viewpoints were more valid than others.

Kuhn found a relationship between reasoning skills and epistemology. As the individuals' claims moved from claims as copies, claims as opinions, facts and claims as judgments; their epistemologies evolved from dualist, multiplists, and to evaluatist. For further research, she suggested to investigate whether epistemological thinking of an individual differs from one domain to another, e.g. in sociology versus in physics (Kuhn & Weinstock, 2002).

2.1.4. Reflective Judgement Model

The last significant stage like theory was introduced by Patricia King and Karen Kitchener. In 1994, they (King & Kitchener, 2002) took a different approach while studying epistemology. They introduced three level model of cognitive process. This model was presented in a study which was published in 1983 by Karen Kitchener. In the study, she focused on adults' reasoning process while solving an ill-structured problem. The first level is called cognition. At this level, individuals employ computing, perceiving, reading and memorizing. The second level is metacognitive process. In this level the person monitors her/his progress while engaging in the actions engaged at cognition level. The last level is called epistemic cognition. People in this level consider the "certainty of knowledge", "limits of knowing" and "the criteria for knowing" while engaging in an ill-structured problem.

They studied the development of epistemic cognition for twenty years. The result in their research program suggested that there are seven reflective judgment stages of epistemic cognition. Since some of those stages were very close to each other in terms of their properties, the researchers classified those stages into three groups: (1) pre-reflective reasoning, (2) quasi-reflective reasoning and (3) reflective reasoning. People who are in the prereflective reasoning category think that knowledge can be gained from an authority and firsthand observations. They also think that their knowledge is the absolute truth. They also tend to approach an ill-structured problem like they approach a well-structured problem. In the second group quasi-reflective reasoning, the people acknowledge that the knowing can be uncertain. However, they hardly con-

nect evidence with a conclusion because according to them those judgments are highly personal. The people who are in the third category (reflective reasoning) accept that knowledge is uncertain. When they make judgments, they try to make it in "the most reasonable" way. The reflective judgement model is a synchronous model as well. The framework introduces the word "epistemic cognition" in the literature. The authors argued that epistemic cognition might be the foundation of critical thinking (King & Kitchener, 2002).

2.1.5. Epistemological Beliefs

Another conceptualization of epistemology in the field of education is personal epistemological beliefs. The framework was introduced by Schommer-Aikins in 1990. She argued that epistemology is a multi - dimensional beliefs system. In parallel with this argument, she developed a belief system which consisted of five dimensions. Those were (1) structure of knowledge (ranges from knowledge is a collection of isolated facts to knowledge is a collection of interrelated concepts), (2) stability of knowledge (ranges from knowledge is certain to knowledge is tentative), (3) source of knowledge (from authority to reason), and (4) speed of knowledge acquisition (ranges from learning occurs quickly to learning is a gradual process) and (5) ability to acquire knowledge (ranges from this ability is a fixed one to this ability can improved) (Schommer-Aikins, 2002). Schommer-Aikins used 63 statements which investigates epistemological beliefs. The participants were asked to rate the statements from 1 (strongly disagree) to 5 (strongly agree). At the end of the study, she obtained continuum scores on each dimension for each participant. She also argued that the five dimensions are independent of each other, hence she challenged the stage like theories. Schommer-Aikins's major contribution to the research on epistemology was to introduce the notion of using a quantitative measurement tool for assessing the epistemological beliefs of individuals (Hofer & Pintrich, 1997).

2.1.6. Personal Epistemological Beliefs

Another conceptualisation of epistemology as a multi-dimensional beliefs system has been done by Hofer and Pintrich (1997). They argued that epistemological beliefs should be limited to personal beliefs' about knowledge, reasoning and justification processes and dimensions related to learning and educational experience should be excluded. They have named to general areas: nature of knowledge and nature of knowing. Each area consisted of two dimensions and those dimensions evaluated on a continuum score. Nature knowledge consisted of the dimensions (1) certainty of knowledge (ranges from knowledge is certain and absolute to knowledge is evolving and tentative) and (2) simplicity of knowledge (ranges from collection of facts to interrelated concepts). Nature of knowing consisted of the dimensions (3) source of knowledge (ranges from source knowledge resides in an external authority to knowledge is constructed in interaction with other) and (4) justification for knowing (ranges from dualist belief of knowledge to acceptance of multiple opinions based on reasoning and justification).

2.1.7. Contributions of Stage Like Theories and Epistemological Beliefs

Perry and his team of counselors were the ones who detected the phenomena. The quantitative measurement developed by Schommer-Aikins, enabled the research on epistemology to be conducted with larger samples. Belenky *et al.*, demonstrated how individuals' perception of knowledge vary according to gender. Kuhn (1991), studied epistemology within the context of reasoning. This allowed her to capture epistemology in action. Also, the results of her study suggested that reasoning and epistemology is connected structures. Another contribution of Kuhn was using ill-structured scenarios in order to elicit epistemologies. Later, this methodological contribution has been used in studies conducted on epistemology by other researchers (Barzilai & Zohar, 2012; Braten *et al.*, 2014; Greene *et al.*, 2021). Kitchener was the first researcher to use the term epistemic cognition (Hofer & Pintrich, 1997) and today it is the most used term by the researchers who study epistemology in field of education (Greene *et al.*, 2016). In addition, the frameworks presented in the previous section were used for

investigating the relationship between epistemology and various aspects of education. Those include the relationship between the epistemology of students and the interaction between the students and the teachers (Roth & Roychoudhury, 1994), the effect of epistemological beliefs on learning approaches, and academic performance (Cano, 2005), the relation between epistemological beliefs, academic achievement and task performance (Lodewyk, 2007), the effects of students' epistemic beliefs and exposure to the criteria for sound scientific argument on the quality of their arguments and learning (Nussbaum *et al.*, 2008), relationship between students' conceptual learning gains and their epistemological preferences (May & Etkina, 2002) and the relationship between students-teachers' epistemological beliefs and their conceptions of teaching (Cheng *et al.*, 2009; Tanase & Wang, 2010). Those studies and many others kept the interest of educational researchers in epistemology alive throughout the years. However, there are issues which those theories fall short in explaining.

2.1.8. Problems with Stage Like Theories and Epistemological Beliefs

The first issue is domain specificity versus domain generality. The research studies (except Kuhn's model) presented in the previous sections has conceptualized the construct of epistemology as a domain general one. However, according to the review paper published by Muis *et al.*, (2006), the results of the empirical studies suggest individuals' perception of knowledge, varies from domain to domain. Perception of knowledge tends to be naiver in well-structured domains where the paradigm is unified and have a more concrete methodology compared to perception of knowledge from an ill-structured domain where the paradigm is more loose (Hofer & Pintrich, 1997). Hammer and Elby (2002) took domain specificity versus domain generality issue further by suggesting that individuals' perception of knowledge might vary within a domain as well. For example, in research study conducted by Mercan (2012), physicists approached a classical physics problem and a frontier physics problem differently. Classical physics problem was based on an established knowledge and involved well-defined procedures. On the other hand, frontier physics problem involved a relation with speculative ideas. Hence, the problem required participants to produce judgments based

on subjective assumptions and available evidence.

The second issue is that the stage like theories and epistemological beliefs investigated individuals' perceptions regarding the theory of knowledge. However, it is not reasonable to expect someone who is not a scientist to have thoughts, beliefs or views about theory of knowledge (Kitchener, 2002).

The third issue is the method used to evaluate epistemology by the early frameworks. Epistemological beliefs relied on questionnaire which consisted of Likert-type questions. Assuming that epistemic cognition is very much dependent on the context, it is not possible to measure such a complex and diverse structure by Likert-type questions (Mason, 2016). For instance, think about two high school students. They think their physics textbook is a valid source of knowledge. They both score high points regarding the validness of the authority. One of them believes that scientists are always right and since the textbook is written by scientists, the textbook has to be a valid source. However, other student recognises that knowledge is tentative. And the knowledge in textbook is a result of repeated experimentation and justified more than other opinions. Even though their final opinion regarding the validness of the textbook is the same, deepness of their reason for coming to that conclusion differs significantly. Likert-type questionnaires fail to capture such differences (Chinn *et al.*, 2011). Hence epistemic cognition needed to be conceptualised by considering these issues.

2.2. Features and Components of Epistemic Cognition

Since, epistemic cognition varies not just from domain to domain but also within the domain, one feature of epistemic cognition is the sensitivity to the context. Another feature is that practices such as producing, evaluating, assessing and communicating knowledge are central to epistemic cognition (Kelly, 2008; Chinn & Rinehart, 2016). Those practices are called epistemic practices. Aligned with these ideas, Clark Chinn and Ronald W. Rinehart (2016), introduced AIR (Aims, Ideals and Reliable processes) framework in order to measure and model epistemic cognition while an individual

engages in an epistemic practice. According to AIR framework, epistemic cognition has three components; epistemic aims, epistemic ideals and reliable epistemic process.

2.2.1. Aims

Epistemic cognition is a process directed according to aims. There are two types of aims; epistemic and non-epistemic. Epistemic aims vary from context to context. A determining factor which defines context, is the related discipline. Value of an epistemic aim is determined by the related field or community. For instance, proving an assertion is true can be considered as a valuable epistemic aim for a mathematician. On the other hand, for a biologist, cloning can be considered as a valuable epistemic aim (Chinn & Rinehart, 2016). In the school context, there can be epistemic aims set by teachers for their students. Those aims differ according to the teachers' orientations. For instance, teachers who were more teacher centered than student centered, set recalling facts as an epistemic aim for their students. More student centered teachers set producing evidence-based arguments as an epistemic aim for their students. Hence, the teachers' orientation influenced how they value different epistemic aims (Rinehart *et al.*, 2020).

In another study, Herrenkohl and Cornelius (2013), studied with sixth grade students to examine the relationship between epistemic cognition and classroom argumentation practices in science and history lessons. The researchers identified defining argument, changing and revising arguments and role of debate in argumentation as epistemic aims for science lesson. For history lesson, evaluating truth claims were identified as an epistemic aim. This is another example how epistemic aims are influenced by the discipline.

Since, assessing is an epistemic practice, teachers engage in the process of epistemic cognition while they assess their students. In a research study conducted by Barnes *et al.*, (2020), the research team observed teachers while they grade their students' works. Goals related to figuring things out and producing knowledge and beliefs were considered as epistemic aims which teachers set for themselves and pursuing

understanding, constructing knowledge and justification were considered as epistemic aims which teachers set for their students. In the study, grading speed expectation was identified as a non-epistemic aim. Another non-epistemic aim was detected in a study conducted by Lindfors *et al.*, (2019). The researchers observed three 16 years old students, while they perform the epistemic practice of problem solving. They identified "having a good time" as a non-epistemic aim. Increasing knowledge related to HIV virus in order to develop better medicine can be given as an example to non-epistemic aims (Barzilai, 2017). Hence epistemic aims can be identified as aims which focuses on producing knowledge, evaluating knowledge or developing an understanding of a phenomenon.

Epistemic cognition can be studied outside of the school contexts as well. Barzilai (2017) examined epistemic cognition of adolescents while they were engaging in an educational simulation game in order to describe epistemic aims, ideals and processes. The aims of the game was to build a city which has quality environment, 200 inhabitants and a developed economy. In the study, Barzilai encountered epistemic aims related to knowing in the game (knowing if a city is good, knowing how to build a good city, knowing about buildings in the game, understanding why something happens in the game), knowing about playing the game (knowing how to play the game, knowing the rules of play) and knowing about the game (knowing how well the game represents real-world phenomena).

2.2.2. Epistemic Ideals

Epistemic ideals are the criteria which are used to evaluate products of epistemic cognition. Those products can be arguments, knowledge, evaluation, models or an understanding of particular case or a phenomenon. Similar to aims, epistemic ideals also vary from context to context. For instance, a scientist might use the following criteria while evaluating their products: trying to find contradictions with evidence, the results' ability to generate new research, consistency of the findings with other studies (Chinn, Rinehart, 2016).

In the study of Lindfors *et al.*, (2019), the participants were asked to bring a seesaw into balance in an online simulation. They manipulated various variables and started the simulation to find out whether their solution brought the seesaw into balance or did it not. In this context, the product was the knowledge produced by the participants to bring seesaw into balance. Hence, after starting the simulation, the seesaw coming into balance meant that the students has produced reliable knowledge. This feedback from the simulation was the epistemic ideal for this case.

Epistemic ideals can be different in a classroom context. In the study of Rinehert *et al.*, (2020), the teachers used measurable improvement on assessment, coverage of the content, transfer of learning (when the students apply the newly acquired knowledge into different situations), when students are able to generate evidence based arguments, accurate personalised explanation and agency (when students are able to lead discussions about the topic) as a way to evaluate products of students' epistemic cognition.

In Barzilai's study (2017), adolescents have answered the following criteria in order to evaluate their products of epistemic cognition while engaging in the simulation game which has the aim to build a sustainable, 200 population city: does produced knowledge provide points in the game, is the produced knowledge supported by in-game evidence, does produced knowledge coheres with players' personal opinions and values.

While teachers assess and evaluate their students' essays, they have adopted standards as ideals. If the standards reflected beliefs about knowledge or subject matter regarding the students' work, the ideals were considered as epistemic. For instance, integrating a quotation into the flow of discussion was an epistemic ideal adopted by teachers (Barnes *et al.*, 2020).

2.2.3. Reliable Epistemic Process

Knowledge can be conceptualized as true beliefs produced by a reliable epistemic process. Reliable epistemic process is more likely to produce true beliefs than false beliefs. This theory is called reliabilism. While producing a scientific model, adopting a reliable process is more likely to result in a good scientific model than a bad one. Similarly, while producing a well justified historical narrative, adopting a reliable process is more likely to result in a well justified narrative than a bad one. According to reliabilisim, humans utilise multiple causal processes to produce beliefs. For instance, using vision in order to produce knowledge regarding the location of an object which is in the same room with you can be considered as a reliable process. Because your belief about the location of the object is most likely to be true. However, using visual perception for this case is reliable under certain conditions, such as availability of adequate amount of light and size of the room. Epistemic processes are causal as well. Observation, evaluating credibility of a study, argumentation, peer review can be given as examples to epistemic processes. Which epistemic process is reliable under which conditions is determined by the scientific discipline that epistemic cognition takes place (Chinn & Sandoval, 2018).

In the context of classroom, the teachers have used reframing, elaboration, reflection, construction and critique. Student centered teachers have used reframing reflection, construction and critique more frequently than teacher centered teachers as a reliable epistemic process in order to attain epistemic aims which was addressing standards and adopting and applying inquiry-oriented instruction (Rinehart *et al.*, 2020). Hence, teachers' orientation affected how they perceive which epistemic process is reliable. In the study of Barnes *et al.*, (2020), reading students' entire entry before starting to evaluate them was used by teachers as a reliable epistemic process.

In the study of Lindfors *et al.*, (2019), high school students used two types of guessing while they were engaging in epistemic practice of problem solving. Those were trial and error and acting out and testing environment. The difference between

those types was that trail-error lacked a systematic approach for solving the problem. Hence, trial-error can be perceived as a non-reliable epistemic process. On the other hand, acting out and testing environment involved efforts for understanding possibilities and limitations of a specific context by testing the simulation. Hence, acting out and testing environment can be given as an example to reliable epistemic process. Thinking (using symmetry, looking for patterns, inquiry, using known skills) was another example to epistemic reliable processes. In the study of Barzilai (2017), adolescents have used observations, testimonies given by the in-game tutorial, memories, cycles of verification and inferences as reliable process of producing well-justified solutions for the challenges presented in the simulation.

In conclusion, the AIR models provides a framework in order to describe epistemic cognition. It conceptualizes epistemic cognition as a goal directed process which an individual engages in while producing or evaluating knowledge. The model reflects the idea of disunity which means there is no common scientific practice among disciplines (Chinn & Rinehart, 2016). Hence, it conceptualizes epistemic cognition as a contextual process. Here, the context can be defined as orientation of the teacher (student centred or teacher centred), norms of the scientific discipline which the epistemic cognition takes place, epistemic practice which epistemic cognition manifests through. This open ended nature of the model allows researchers to capture the process of epistemic cognition in various contexts and along various practices.

The stage like theories and epistemological belief theory identified perceptions such as thinking knowledge as a collection of unrelated smaller pieces of information, assuming knowledge is certain and considering the authorities as the only legit sources of knowledge as naive epistemologies. On the other hand, thinking knowledge as a collection of related smaller pieces of information, assuming knowledge is tentative and considering peers and the self as legit sources of knowledge were identified as sophisticated epistemologies. And mostly sophisticated epistemology was considered as epistemology of the experts (Elby & Hammer, 2001). Hence, reaching to sophisticated epistemology was presented as an end point in those theories. Then this question

arises; what is the end point in the theory of epistemic cognition? Even though, AIR framework is an adequate model for describing the process of epistemic cognition, it fails to offer an end point. Also, epistemic cognition conceptualizes epistemic performance as a cognitive level process. By doing so, it overlooks the metacognitive aspects of an epistemic performance (Barziliai & Zohar, 2016). Hence there was need for a theory which describes epistemic performance both at cognitive level and metacognitive level. In order to fulfill this need, Barzilai and Chinn (2018) introduced Apt-AIR framework. In Apt-AIR framework, end point for epistemic performance is the ability to demonstrate apt epistemic performance.

2.2.4. Apt-AIR Framework

Apt-AIR framework defines five aspects of an apt epistemic performance: (1) cognitive engagement in epistemic performance, (2) adapting epistemic performance, (3) regulating and understanding epistemic performance, (4) caring about and enjoying epistemic performance, and (5) participating in epistemic performance together with others. Each aspect can be observed in each component of epistemic cognition: epistemic aims, epistemic ideals, and reliable epistemic process. Epistemic performance can be defined as achieving epistemic aims. If the set epistemic aims are valuable and those are achieved through competence, then the epistemic performance can be identified as apt. In the APT-AIR framework cognitive level is described by AIR components and metacognitive level is described by the aspects of apt epistemic performance (Barziliai & Zohar, 2016).

To test the framework, a study was conducted by Greene, *et al.*, (2021). The study was conducted to explore how experts transfer their ability to engage in apt epistemic performance from their own discipline of expertise to another discipline. The participants of the study consisted of a psychologist who has a clinical psychology background, another psychologist who has social psychology background, a sociologist, an anthropologist, a physicist and a chemist. Each of the participants were experts in their fields of study. The all had more than five years of post-PhD experience.

The study was designed in order to investigate the following questions: "In what ways does the Apt-AIR model capture how university professors evaluate claims and arguments?" and "how do university professors transfer their disciplinary apt epistemic performance to understand a controversy outside of their discipline?". To answer these questions, the participants were given four conflicting articles about the replication crisis in the field of psychology. The data was collected via think aloud sessions.

Each participant was able to demonstrate different aspects of apt epistemic performance while evaluating conflicting claims presented by the articles regarding replication crisis in the field of psychology. In addition, components of epistemic cognition were observed as well. For instance, obtaining funds was identified as a non-epistemic aim, producing novel knowledge was identified as an epistemic aim, small ρ-values were identified as an epistemic ideal and using multiple ways of knowing was identified a reliable process for producing scientific knowledge.

2.2.5. Aspect 1: Cognitive Engagement in Epistemic Performance

For an apt epistemic performance to occur, individuals should be able to identify epistemically valuable products to aim for. This might involve selecting important questions for investigations (e.g., How does COVID19 infect people?) or identifying valuable knowledge to solve a problem. Hence, according to the context epistemically valuable aims varies (Greene *et al.*, 2021).

In terms of epistemic ideals, the individuals should be able to identify appropriate ideals, to evaluate, communicate and create the products of epistemic cognition which might be models, prior knowledge, arguments, judgments, and so on. Appropriate ideals vary from context to context.

For the achievement of epistemic aims, individuals should be able to engage in cognitive processes which are called reliable epistemic processes, while considering appropriate epistemic ideals. Like other two components, reliable epistemic processes are

contextual as well. For instance, constructing a mathematical proof might be used frequently in physics while achieving epistemic aims. However, in psychology, conducting observations might be a more frequent process which leads to the achievement of epistemic aims (Barzilai & Chinn, 2018).

2.2.6. Aspect 2: Adapting Epistemic Performance

Epistemic cognition is a process which is heavily influenced by the context. Hence, an apt epistemic performance requires adaptability to the context at hand. There are two factors which affect the second aspect. The first is to show sensitivity to the specific demand and conditions of various situations. This factor suggests that while identifying epistemic aims, epistemic ideals and reliable epistemic processes, it is required to consider the constraints of the context, task and the discipline in order to achieve epistemic aims. The second is having a large repertoire of reliable epistemic processes. This will increase the likelihood of adapting reliable epistemic process in the particular context. A physicist applying her/his understanding of replicability of an experiment to the results of a replication study in psychology successfully can be given as an example to the second aspect.

In the study of Greene *et al.*, (2021), one of the psychologists had to construct an understanding regarding the replication crisis in order to understand the conflicting articles. The other psychologist had prior knowledge about replicability issue. Hence the other one did not had to adapt her apt-epistemic performance. Social scientists and natural scientists had to go through an adaptation process as well.

2.2.7. Aspect 3: Regulating and Understanding Epistemic Performance

Third aspect of apt epistemic performance emphasizes the importance of metacognitive knowledge and skills, while engaging in an epistemic performance. There are two components of aspect 3. The first one is the epistemic metacognitive skills. Those skills are required to regulate epistemic performance. It consists of epistemic planning, epis-

temic monitoring and evaluation and epistemic control. Epistemic planning is the process of forming plans or intentions in order to achieve epistemic aims. Epistemic monitoring and evaluation are the process of deciding whether epistemic processes result in successful epistemic aims. Epistemic control is the ability to identify and adopt alternative epistemic processes which result in more reliable and efficient epistemic outcomes. In the study of Greene *et al.*, (2021), the natural scientist suggested that there should be a guideline for how to conduct best replication. This was example for epistemic planning.

The second component of the third aspect is epistemic metacognitive knowledge. In terms of epistemic aims, understanding why some aims are more important than others and identifying important aims is considered as a component of this aspect. For epistemic ideals, understanding why evaluation criteria or epistemic norms are important is an epistemic metacognitive knowledge. In terms of reliable epistemic process, identifying why some epistemic processes are likely to result in a more reliable epistemic product than others and when specific epistemic processes are likely to succeed in producing epistemic product can be given as examples for the second component of this aspect (Barzilai & Chinn, 2018).

In the study of Greene *et al.*, (2021), the psychologists were able to understand what replicability issue means for the discipline of psychology. Also, they were able to understand when and why statistics are used as an accepted research method in psychology. In addition one of the psychologists stated due to this criticisms, as a discipline perhaps there is a need to refine scientific methods. By doing so, s/he demonstrated epistemic metacognitive knowledge regarding reliable epistemic process which identifying process which is likely to produce well justified beliefs. The social scientists demonstrated a metacognitive understanding of epistemic aim of developing invariable knowledge for the field psychology. The natural scientists in the study was able to demonstrate aspect 3 as well. In terms of replicability, they valued the reliable process of providing help to those who would like to replicate your research.

2.2.8. Aspect 4: Caring About and Enjoying Epistemic Performance

A cognition is epistemic only if it is directed at an epistemic aim (Chinn, 2011). Hence, being motivated about pursuing epistemic aims antecedent to achieving them. Motivation is also important while applying epistemic ideals and using reliable epistemic processes as well. Motivational dispositions can be curiosity, wonder, love of truth and intellectual responsibility (Barzilai & Chinn, 2018). For instance, an intellectually responsible scientist cares about scientific evidence while pursuing an epistemic aim or a scientist might be motivated to pursue an epistemic aim for the sake of love of truth. In both cases, they demonstrate the fourth aspect of an apt epistemic performance.

2.2.9. Aspect 5: Participating in Epistemic Performance Together with Others

According to Kelly (2008), the process of producing or evaluating knowledge is a social one, since norms which determines the ways to produce and evaluate reliable knowledge is determined by scientific communities. In parallel with this assumption, the fifth aspect emphasises the social nature of apt epistemic performance by acknowledging broadcasting and producing knowledge is achieved in social configurations. While an individual demonstrates epistemic performance, she has to be aware of the social norms regarding knowledge production and dissemination processes.

2.3. Conclusion

The study of Greene *et al.*, (2021) provides insights for understanding epistemic performance of experts and their ability of critiquing complex ideas. It is a unique study, since Apt-AIR framework has been adopted to describe the apt epistemic performance demonstrated by the experts. In addition, the study provides various examples for the components of epistemic cognition. According to the Next Generation Science Standards, it is important for students to demonstrate epistemic competence and epistemic meta competence in order them to become informed citizens (Greene

et al., 2021). Considering this intention, it is reasonable to expect future teachers to have the ability to demonstrate apt epistemic performance in their areas of expertise and ability to transfer these performances to another field outside of their field of expertise. This ability is also a requirement for citizen to take an accurate and a well justified decisions regarding issues related with personal health and society. This type of investigation also requires an exploration of cognitive and metacognitive elements of epistemic performances of experts. In alignment with these ideas, I proposed an exploratory research study. Considering the various advantages and disadvantages of the frameworks presented in the literature review, I have employed Apt-AIR framework as an analytical framework. The study focused on those four research questions stated at the introduction section.

3. METHOD

Aligned with the literature review, the aim of the study is to investigate teachers' epistemic performance. In method section, summary of analytical framework, participants of the study, research setting, data collection, data analysis and trustworthiness of the proposed study are presented.

Table 3.1. List of metacognitive elements of epistemic performance (aspects of apt epistemic performance).

Aspect of Apt Epistemic Performance	**Definition**
Aspect 1: Cognitive Engagement in Epistemic Performance	Ability of selecting important questions and identifying valuable knowledge
Aspect 2: Adapting Epistemic Performance	Adapting epistemic performance according to constraints of the context.
Aspect 3: Regulating and Understanding Epistemic Performance	Ability to employ metacognitive skills to regulate epistemic performance, identify appropriate aims, ideals and process and understand why they are important.
Aspect 4: Caring About and Enjoying Epistemic Performance	Being motivated about pursuing epistemic aims and being motivational about applying epistemic ideals and reliable processes.
Aspect 5: Participating in Epistemic Performance Together With Others	Acknowledging broadcasting and producing knowledge is achieved in social configurations

As stated in the literature review and introduction sections, Apt-AIR framework has been used as an analytic framework. Detailed explanation of the framework has

been done in the literature review. In the tables below a summary of aspects of apt epistemic performance in other words metacognitive elements of epistemic performance and components of epistemic cognition in other words cognitive elements of epistemic performance can be seen:

Table 3.2. List of cognitive elements of epistemic performance (components of epistemic cognition).

Components of Epistemic Cognition	**Definition**
Epistemic Aim	Aims which people set while demonstrating epistemic performance
Epistemic Ideal	Criteria used to evaluate products of epistemic performance
Reliable Process	Processes which are more likely to produce true beliefs than false beliefs

3.1. Participants

To examine varying levels of expertise in physics, two physics professors and four teaching physics students was included in the study. In order to examine varying field of expertise, four social science undergraduate students were included. The participants were grouped into three according to their background differences: (a) physics professors (physicists), (b) teaching physics students and (c) social sciences students. The number of participants for each group is given in the Table 3.3. In total there were 10 participants.

Table 3.3. Number of participants by groups.

Group	N
Physics Professors (Physicists)	2
Teaching Physics Students	4
Social Sciences Students	4
Total	10

The physics professors were chosen because they were expected to set an example to apt epistemic performance in the field of physics. In terms of the controversial issue, physics professors provided qualitative data on how expertise can be transferred to a domain where they are not experts. As discussed in the literature review, transferring ability of demonstrating apt epistemic performance from one discipline to another is a requirement of today's society. To detect possible differences which, the students have in terms of demonstrating this ability, students of two different fields of discipline were included: physics and social sciences. Since the participants were chosen intentionally for investigating the phenomenon of epistemic performance, the type of sampling was purposeful sampling (Creswell, 2012). Physics professors were from a public university, and the students were undergrads from the same university. Both physics professors have received their PhD degrees in the field of physics. Hence, it is the assumption of the study that their epistemic performance demonstrated within the context of the first issue (fine tuned universe) is apt. The participants were contacted and asked to participate in the study. Participating in the study was voluntary. One of the physics professors, two of the teaching physics students and two of the social sciences students have participated through online sessions. One of the physics professors, two of the teaching physics students and two of the social sciences students have participated through face to face sessions.

3.2. Research Setting

The university where the physics professors work and the students study is in İstanbul, Turkey. Physics professors are working in the state funded institution which have approximately 17.000 students. There are about 300 students enrolled in the physics department of the institution of which about 50 are graduate students.

Studying ability of demonstrating apt epistemic performance in Turkey gave the researcher the opportunity to explore the phenomenon in a country different than United States. In addition, conducting the research with Turkish speakers have enhanced the communication between the participants and the researcher, since the researcher is a Turkish native speaker as well.

Apt epistemic performance is defined as the ability to reach well-grounded conclusions while engaging in activities such as developing knowledge or achieving a deep understanding. To understand the phenomenon of epistemic performance, individuals' epistemic performances while they engage in such activities need to be studied. Such a study requires a detailed description of epistemic performance. Hence to answer the research questions, a qualitative approach was adopted. During this process, aspects of the participants' epistemic cognitions were explored. As data collection methods, think aloud protocol and semi-structured interviews were used.

3.3. Data Collection

3.3.1. Think-Aloud Protocol

Think - aloud protocol (TAP) has been around since the first half of the 20th century. Researchers such as John B. Watson and Karl Duncker were the pioneers who have adopted this method. They have asked the participants to verbally express their thoughts while they engage in a problem solving activity (Ericsson, 2018). However, during those times the researchers could not clearly identify where and when the

data obtained from think aloud protocol, can be useful (Fox *et al.*, 2011). Later, in 1950s and 1960s, psychologists have started to study constructs related to problem solving by obtaining and analysing data from verbalised solutions due to interest in constructing computer programs which can perform challenging cognitive tasks (Ericsson, 2018). During the data collection process, the participants were asked to explain their method of solving task. Some researchers argued, this asking undermines the validity and the accuracy of the data by interfering with the cognitive process. In order to overcome this issue Anders Ericsson and Herbert Simon introduced several elements which enable researchers to collect consistent, valid and non-reactive reports regarding the thoughts of the participants. They assumed that it is possible to verbalise thoughts without altering them. According to Ericsson and Simon, there are three levels of verbalizations which occur when people are asked to think aloud. The first level refers to verbalizations which reflect the consciousness directly and immediately. The second level of verbalization happens when additional step is required to convert cognitive process into verbalization. For instance, conversion of sensory information into language and voice is an example for second level (I see red balloons) (Greene *et al.*, 2018). The third level represents reactions which the participants normally would not produce. For instance, as participants are speaking, the researcher asks the participant to explain her/his thoughts. S/he reacts to this prompt and produces a response. This additional response is considered to be a level three verbalization since it will not be produced normally. Think aloud protocol aims to elicit first and second levels of verbalizations. Eliciting level three verbalization is not desired because it is considered to be disruptive to cognitive processes (Ericsson, 2018).

Before starting to collect data by using think-aloud protocol, the participants should be informed by the method. Furthermore, they need to be given time in order to practice TAP. As a TAP practice, the following task introduced by van Someren (1994) will be given to the participants before beginning the study: "This task consists of inventing improvements for technical devices. I shall give you the name of a technical device and your task is to invent five improvements of this device. Some possible devices are: washing machine, telephone, and elevator" (p. 177).

During data collection, the interaction between the researcher and participant has to be at minimum. Researcher sitting out of participants' sight is one way to ensure this. If the researcher is able to keep the interaction at minimum, the participants will feel like talking to themselves. This will lead to more accurate data. Another thing to consider during the implementation of TAP is to choose appropriate prompts. When participants stop talking, the researcher should prefer prompts such as "keep talking", since it helps to keep the interaction between the participant and researcher at minimum. Prompts such as "say what you are thinking" would encourage participant to produce additional verbalization. This type of verbalization is an example to third level of verbalization which is not a desired behavior during TAP.

TAP is used for capturing expertise in action. Through analysis of the obtained protocols, I argued that elements of APT-AIR model can be studied.

3.3.2. Semi-structured Interviews

Verbalisation is the working memory expressed aloud in words. In working memory, only the active information is located. Even though, TAP is successful in terms of capturing components of epistemic cognition, there is a need to study long term memory as well. Information stored in long term memory is more or less permanent compared to information stored in working memory (van Someren, 1994). According to the literature review, apt epistemic performance is present at both cognitive and metacognitive levels. To detect possible information regarding the metacognitive level, there was a need to study long term memory as well. In order to fulfill this need, semi-structured interviews were conducted with the participants right after the think aloud part. In order not to interfere with the thought process of the participants, the interviews were conducted right after the think aloud part.

3.3.3. Materials

As stated in the literature review, tasks which include controversial issues elicit epistemic performance. Aligned with this assumption, two controversial issues were presented to the participants through YouTube videos: "Is the universe fine-tuned for life" and "Should Covid19 vaccine be mandatory for healthcare workers such as doctors and nurses?". In the videos, different points of views and supporting knowledge claims regarding the issues have been presented. Both videos had English and Turkish subtitles. Also, during the data collection process, English and Turkish transcripts of both videos were provided to the participants. While watching the video, the participants were allowed to pause the video, adjust the volume of the sound, seek forward or backward and jump to any second.

Regarding the first issue, a YouTube video was given to the participants (Closer to Truth, 2013). In the video, an interview done with Leonard Susskind a physics professor from Stanford University, has been recorded. In the video, Susskind explains what fine-tuned universe is. According to Susskind, the laws which explain how universe is evolved, are unique. Those laws seem to be fine-tuned, so that life can flourish in the universe. Later, he presents knowledge claims which support different points of view aimed to explain why or how the universe seemed to fine-tuned. The first point of view is the God. The second one is our universe is created accidentally. The third one is there are multiple universes, and our universe is just among those universes where life has happened to flourish in it. The video is fourteen minutes and forty-five seconds length. The video and the transcript of the video will be given to the participants with accompanying questions. Those questions are:

- What do you think about the knowledge claims presented in the video regarding fine-tuned universe?
- Do you think, our universe is fine tuned for life? What are the reasons you hold that view?

The participants will be asked to produce answers to those questions as they engage with the video.

Regarding the second issue, another video from YouTube was given to the participants (Good Morning Britain, 2022). In the second video a discussion takes place between two different points of view regarding the issue, mandatory Covid vaccine for healthcare workers who are in direct contact with patients. James is an anesthetist who works in National Health Service (NHS) in United Kingdom. James is against the NHS Covid vaccination requirement mandated by the government for all NHS staff who has direct contact with patients. Jones is general practitioner and a health editor. He supports the government's mandate. The video is nine minutes and forty-four seconds long. The video and the transcript of the video will be given to the participants with accompanying questions. Those questions are:

- What do you think about the knowledge claims presented in the video regarding mandatory Covid vaccines for healthcare workers who are in direct contact with patients?
- Which of the doctors do you agree with Dr. Steve James or Dr. Hilary Jones? What are the reasons you hold that view?

The participants were asked to produce answers to those questions as they engaged with the video.

Before data collection, the approval from the Institutional Review Board for Research With Human Subjects has been obtained from the authors' institution. The data collection was conducted individually. Prior to each sessions, consents of the participants have been taken. Each participant's think aloud session was followed by a semi structured interview. The duration of the sessions and interviews ranged from 47 minutes to 89 minutes and 8 seconds. All think aloud sessions and interviews were audio recorded. There were two recording devices just in case one of them breaks down during the sessions. As recording devices, a voice recorder and a computer were used.

The audio recordings have been transcribed verbatim for analysis. The room where data has been collected was protected against external distracting sounds. Before beginning to think aloud session, each participant was asked to complete "Think-aloud Exercise". During data collection, if participant stayed silent for more than fifteen seconds, s/he were given the following prompt: "Keep talking".

The semi-structured interview questions are adopted from the study of Mercan (2007) (p.50). After each think aloud session, those questions were asked to the participants:

- What leads you to hold that point of view?
- On what do you base that point of view?
- How confident are you about your point of view?
- Can you ever know that your point of view is correct? How or why not?
- Can one of the knowledge claims be right? What do you mean by right?
- Can one of the claims be better? What do you mean by better?
- How is it possible that experts in the field disagree about this subject?

In the semi-structured interview of the second video, there are two additional questions:

- You have watched two videos. In terms of knowledge claims, can you compare them for me?
- While choosing a point of view for both issues, what were the differences you have encountered due to the different natures of the issues?

The aim of those questions were to explore how participants' epistemic performance adapts according to different disciplines.

3.4. Data Analysis

All data was transcribed verbatim. The transcripts then were coded. In order to manage the coding of the data, MAXQDA software was used. The coding process can be defined as conceptualising data. Hence a code is the product of this process (Strauss, 1987). The analysis adopted the constant comparative method in which there are three types of coding process (Cresswell, 2012). The first type of coding is open coding. This is the initial step of the coding process. In open coding, data is analysed line by line and data is coded without any restrictions. The second step of the coding process is the axial coding. In axial coding, codes detected during the open coding process are collected under categories. These categories can include information about categories of conditions, specific context which influences a strategy, a phenomenon which is central to the examined process, specific conditions which influence a strategy or consequences of an adopted strategy (Cresswell, 2012). The third step of the coding process is selective coding. During selective coding, researcher aims to form connections between categories. Also, the excluded codes from the axial coding process are examined once more and some of them are excluded completely or connected to the categories (Strauss, 1987). Hence, compared to open coding, selective coding is more systematic. The process form open coding to selective coding is an iterative one. The whole process is called constant comparative method. This method was introduced to generate a grounded theory, but the current study does not claim to generate such a theory. Rather, due to compatibleness of the method with the inductive qualitative research design, it was employed by researchers who does not aim to build a theory as well (Merriam, 1998). So, while the nature of this study is not grounded theory, I employed the constant comparative method. In the study, I have adopted APT-AIR framework where the codes and categories are borrowed from Greene *et al.*, (2021). Hence, at the end of the analysis, I expect my codes and categories to fit into APT-AIR framework. Any differences will be reported.

3.5. Trustworthiness

How a researcher can persuade the audience that the findings can be accounted for is the concern of the trustworthiness of the study (Lincoln & Guba, 1985). Considering the aim of the study, the trustworthiness is whether how, apt the participants' epistemic performance is, and they can adapt their epistemic performance to issues from different fields are consistent with the Apt-AIR framework presented in the literature review.

To enhance the trustworthiness of the study, inter-rater reliability strategy was used. Another researcher who studied epistemology and has a PhD degree in education coded the data as well. Another action taken for enhancing the trustworthiness was the way which issues are presented. Both issues were presented through videos accompanied with the transcripts of the videos. This has ensured the issues are presented to the participants through the same communication channels. By doing so, a possible factor which might affect the data collection process was eliminated. Another factor which contributed to the trustworthiness was the language. The researcher and the participants had the same native language. This helped the researcher to communicate with the participants more efficiently and clearly. To investigate different facets of epistemic performance, data has been collected via think aloud and semi-structured sessions. Collecting data via different techniques contributed to the trustworthiness of this study. Another action which I have taken to enhance the trustworthiness is providing a detailed, rich thick description of the data analysis process (Merriam, 1998).

4. FINDINGS

At this chapter, the findings are presented with examples from the transcribed data. The chapter starts by presenting findings from the physicists. The second part of this chapter is findings from the teaching physics students and the third part is findings from the social sciences students. Lastly, comparison in terms of types of cognitive and metacognitive elements of epistemic performance of three groups with respect to each issue has been presented.

4.1. Findings from the Physicists

In the data of the two physicists there were no contradictory statements. Their sessions completed each other.

4.1.1. On Nature of Physics from the Eyes of the Experts

Both physicists have leveraged their understanding of physics as a discipline. Physicist A has demonstrated an understanding for epistemic planing [aspect 3] by summarising the process of forming plans to achieve epistemic aims. The plan included setting up the theory and checking it by conducting an experiment. For example he said:

> Physicist A: Now between universes - what Susskind claims and the physicists' approach is that there is no relationship between those universes. Otherwise, if I have no relationship with them, namely if I cannot keep them under control, what happens there is not my con-cern in terms of physics. Because physics is something like in which I'll set up its theory, conduct its experiment, and check it out.

Physicist A has made a distinction among theories in physics as well: good theories and bad theories, thus demonstrating an understanding of metacognitive knowledge regarding discipline of physics [aspect 3]. According to him a good theory has to be

simple and well connected with predecessor theories in physics or with theories from other disciplines. However he had one ultimate criteria which he used to distinguish a good theory from the bad one: a good theory must actually work [epistemic ideal of actually working]. Under-standing whether a theory works or not can be understood via experiments [reliable process of doing experiments to achieve the epistemic aim of evaluating whether a theory works or not]. This is also an implication aspect 1 [aspect 1, identifying valuable aims and choosing appropriate reliable processes to achieve those aims]:

> Physicist A: Better theories always... That's how theoretical physics works anyway. There may be alternative candidates, one of these candidates may be better, and the other may be worse. It is what we mean by goodness and evil, the matter of goodness is a bit subjective, namely, it is depend on that.. we have certain expectations, you know, we want everything to be simple to some extent, so the simpler the better. If it is simpler, it is better. If it is as close as to the theories, and equations that we know, or it surpasses them that's a good thing now. For example, let's say, Einstein connects general relativity to Lehmann geometry, namely differential geometry, which creates the additional beauty. There's a differential geometry, that connects to it. The warping of space-time and so on, that's a good thing. He says in this sense. Think about it, you are creating general relativity, in this case, there have been such situations in string theory, but there is no such mathematics, it is not understood like that, how can such a thing happen, it is not such a situation. As I said there, it had geometry, it connects with it. In this sense, I casually say that this is a better theory. There is another the-ory, but there are no other features, the formulas are incredibly difficult, nothing, namely what I mean through incredibly difficult is complexity, it doesn't have the symmetry, so on. We can make such a visual image or such an intuitive thing, but ultimately let's say, what is measure by this experiment is the victory of one theory over another. No matter how well Einstein calls general relativity, the possibility of such a theory, that is, without contradic-tion, is nice, but if it does not work in accordance with its place as a result of the experiment, it will not work. So he's going to look for another theory.

While talking about the first issue. They have made inferences regarding the importance of issue of fine tuning for physics, thus demonstrating metacognitive understanding of their field [aspect 3]. Physicists agreed whether the universe is fine tuned for life or not is a question for philosophy rather than physics. Here is a quotation from physicist A regarding the issue:

> Physicist A: Susskind actually confuses the questions. Whether gravity is weak or strong is not related to the fine-tuned argument. If gravity was a powerful force now, he probably wants to say in what follows that stars wouldn't have formed, and so on. Okay, the starts wouldn't be formed but something else would be formed. It is obvious that the forces are in the energies in which we live and measure. Each of them is different, and gravity is a very weak force compared to the other forces. However, this is the case with the energies we measure. We don't know how gravity works at higher energies. In this sense, effectively gravity is so weak. Maybe gravity is a strong force, we can't know it at high energies. Prob-ably most theories are based on it. The problem of the hierarchy of forces is that different forces including some stronger and some weaker, have a more effect on the formation of something, but again, how much this is a physical question is another matter, it's more of a philosophical question.

Physicist B has made a very similar claim regarding the importance of issue of fine tuning for physics [aspect 3]. Furthermore, he has also explained why he thinks that way. By do-ing so, physicist B has demonstrated a greater depth of metacognitive knowledge about physics. He has explained lack of experimentation regarding why the initial conditions of the universe were like that is the reason why the question whether the universe is fine tuned or not is not a scientific question. Hence can be experimentally proven has emerged as a criteria for a scientific question [epistemic ideal of can be experimentally proven]. This was also an indication of a metacognitive understanding regarding an epistemic ideal [as-pect 3, metacognitive], since the criteria defines a general feature of a scientific question:

> Susskind: Physicists have a habit of talking in that language, "whoever made the universe", they don't really mean it. But whoever made the universe made it with an incredibly small tiny cosmological constant. It is so small that it is point zero zero zero zero zero... we can sit here for a while, a hundred and twenty-three of them Interviewer (from the video): ...and then a one.
> Susskind: ...and then a one.
> Physicist B: We don't know the quantum theory of gravity. It's caused by it.
> Susskind: I think it is actually a two. But it is incredibly small and nobody really knows why. Physicist B: You can't know its reason. Why can't you know? Because this is not a scientific question. So it's a matter of philosophical debate. In other words, we don't have an experi-ment to test why the conditions of the beginning of the universe were like that, we don't have anything. There is not even a theory at the moment.

In the same quotation physicist B has also presented experimentation and testing as reliable processes to reach trustable knowledge. He further explained why those are reliable, thus demonstrating an understanding for research method in physics [aspect 1]. He has emphasised the importance of repeatable experiments as well [aspect 5]:

> Physicist B: That comes from the data. Now, it determines like this: as it is higher science, we do experiments, we make observations. In physics, knowledge comes from experimenta-tion and observation. Determining things are experiments and observations. Not someone, that is, not a person, but experiments and observations.
> Researcher: Okay
> Researcher: Okay
> Physicist B: Let me tell you something else here. Researcher: Okay
> Researcher: Sure Physicist B: These experiments and observations must be repeatable by others. The models and hypothesis they put forth have to be falsifiable. You have already known that if there is no way of falsification it is not scientific. And if anyone in the world can't repeat your exper-iment, this is not reliable information, it usually turns out to be wrong. There are many such cases. So what I said is based on repeatable observations and experiments. It's not based on what someone says.

In the same instance, physicist B has also demonstrated an understanding of social aspect for discipline of physics by emphasising the involvement of other scientists in repeating experiments [aspect 5]. Similar understanding has been demonstrated by physicist A as well. In the same instance, he has demonstrated an understanding regarding the constraints of a certain theory (Newton's Laws of Motion). This inference about constraints regarding certain contexts in physics is an implication for aspect 1:

> Physicist A: You do the experiment 50 times. You did it and it was proved to be right, you did it and it was proved to be right, you again did it and it was proved to be right, you did it and it went wrong, which means that the theory is not correct or something goes wrong an-yway. However, if the experiment always gives the same thing, that is, the value result is Newton's mechanics. Newton created his equation so cars work, we walk, everything works, so in the end there is no deviation in Newton's theory. I'm speaking about certain energies, I'm speaking about certain speeds. However, there is no deviation there, there is no such thing that we built a car, "Oh, Newton mechanics does not work for this car." There is no such thing, it works.

In another quotation, physicist B has reached a conclusion regarding the first issue through commenting on data, thus cognitively engaged in epistemic performance [aspect 1, process]. Hence, commenting on data emerged as a reliable process. He has also acknowledged the data may change in the future. By doing he has expressed a metacognitive understanding for reliable process in the discipline of physics [aspect 3, process]:

> Physicist B: That's right, he expressed greatly.Nice. Exactly. I agree. Well my personal opin-ion: The universe is not a place specially designed for human, there is no such thing. There is no sign that such a thing happened. There is nothing like that unfortunately.
> Researcher: Well, what leads you to this point of view?
> Physicist B: Physics and biology, physical and biological sciences.
> Researcher: Well, what do you base your point of view on?
> Physicist B: I base it on my physics and biology education.
> Researcher: How sure are you from your point of view?
> Physicist B: Frankly, there is no such thing as being sure. So, when I say I am one hundred percent sure I contradict myself. Let's just say, when I interpret the data at hand, as physi-cists would say, it looks like this, but tomorrow or one day my interpretation may change. If I change the data at hand, it will also change, but when I make a comment by looking at the data so far, I can say this.

In the video about fine tuned universe, Susskind has stated four possible explanations or answers on how or by whom the universe is fine tuned. Two of them were "god" and "by accident". Physicist A has argued those explanations are not scientific since they don't lead to further discussion. He has presented this as a criteria in other words, as an epistemic ideal, for scientific answer or explanation, thus stated an epistemic ideal and a metacognitive understanding of physics [aspect 3, ideal]. He explained if this criteria is not meet, then the issue becomes faith not science:

> Physicist A: For instance, Susskind says that I'm a supporter of chance, and I'm supporter of God. In this case, there's nothing we can discuss with Susskind after that. Because this is a matter of belief; therefore, we can neither do experiment on what he believes, write a formula, or put forward a theory. I say/ defend that God created the fine-tuned, and he says that it's a coincidence. At this point, none of us can get into anything like negotiation or the topic that we will talk about... If the answer is God for someone, the matter is over. This is a matter of faith.

In conclusion, the combination of findings from the physicists help us to picture what apt discipline of physics looks like. In Table 3.3 aspects metacognitive elements of epistemic performance and examples demonstrated by physics professors can be seen:

Table 4.1. Cognitive elements epistemic performance demonstrated by physics professors.

Aspect of Apt Epistemic Performance	Example Quotation
Aspect 1: Cognitive Engagement in Epistemic Performance	*Physicist B: That comes from the data. Now, it determines like this: as it is higher science, we do experiments, we make observations. In physics, knowledge comes from experimentation and observation. Determining things are experiments and observations. Not someone, that is, not a person, but experiments and observations.*
Aspect 3: Regulating and Understanding Epistemic Performance	*Physicist B: You can't know its reason. Why can't you know? Because this is not a scientific question. So it's a matter of philosophical debate. In other words, we don't have an experiment to test why the conditions of the beginning of the universe were like that, we don't have anything. There is not even a theory at the moment.*
Aspect 5: Participating in Epistemic Performance Together With Others	*Physicist B: These experiments and observations must be repeatable by others. The models and hypothesis they put forth have to be falsifiable. You have already known that if there is no way of falsification it is not scientific. And if anyone in the world can't repeat your experiment, this is not reliable information, it usually turns out to be wrong. There are many such cases. So what I said is based on repeatable observations and experiments. It's not based on what someone says.*

In Table 4.1, example quotation of cognitive elements epistemic performance of physics pro-fessors are given.

Table 4.2. Cognitive elements epistemic performance demonstrated by physics professors.

Components of Epistemic Cognition	**Example Quotation**
Epistemic Aim	*Physicist A: Now between universes - what Susskind claims and the physicists' approach is that there is no relationship between those universes. Otherwise, if I have no relationship with them, namely if I cannot keep them under control, what happens there is not my concern in terms of physics. Because physics is something like in which I'll set up its theory, conduct its experiment, and check it out.*
Epistemic Ideal	*Physicist A: Better theories always... That's how theoretical physics works anyway. There may be alternative candidates, one of these candidates may be better, and the other may be worse. It is what we mean by goodness and evil, the matter of goodness is a bit subjective, namely, it is depend on that.. we have certain expectations, you know, we want everything to be simple to some extent, so the simpler the better.*
Reliable Process	*Physicist B: That comes from the data. Now, it determines like this: as it is higher science, we do experiments, we make observations. In physics, knowledge comes from experimentation and observation. Determining things are experiments and observations.*

4.1.2. Physicists' Approach to the Second Issue

The second issue was about covid vaccine. Hence the main discipline related with it was not physics. Since, the issue concerned the society, the physicists had to be concerned with it as well at some point in their lives. While they were thinking about the second issue they had to adapt their understanding of the discipline of physics.

In the previous part, there was an emphasis on experimentation, observation and data. Similar emphasis has been done for the second issue as well. Physicist A has argued, that there were adequate amount of data to reach the conclusion that the covid19 vaccine was safe [aspect 2, adaptation]:

> Physicist A: Not wanting to be vaccinated... It's hard to say something because I'm not an expert on this subject. Maybe it should be listened their arguments. However, science isn't knowledgeable enough on a subject, it might be at first. In January 2022, sufficient data has probably been came into existence , and he sees the results of vaccination. Now he probably talks about the harmful effects/ sides of the vaccine. It (harmful side) probably can be. There is such a situation in everything. But if we put the scales, the harmful parts of being vaccinated, the vaccination will become more important.

Similarly, physicist B has also looked at the adequacy of data while deciding whether covid19 vaccines are safe not [aspect 2, adaptation]:

> Researcher: You said that you did not agree with Doctor Steve James, but you agreed with the second-speaking doctor.
> Physicist B: Now. I said that I agreed like this: I don't know when this talk is. I don't know its date.
> Researcher: on January, 2022
> Physicist B: If it is on January 20, 2022, there is enough data. That is, it is not true to claim that there is no data.

In the interview, physicist B has explained how he has decided Covid vaccine is safe or not. Apparently he read articles to understand side effects of the vaccine. Hence reading articles emerged as a reliable process. He has also tried to understand why there is a need to get vaccinated for Covid disease. He understood there was no benefit for his son to be vaccinated. However, physicist B got his son vaccinated so

that he would not infect other people. Hence, being beneficial to the health of the society emerged as criteria for a decision taken regarding the second issue [aspect 1, ideal]. While deciding which process is reliable while reaching a conclusion regarding the trustworthiness of covid vaccine, he has adapted his expertise from the field of physics to another one [aspect 2, adaptation]:

> Physicist B: Because as I was vaccinated, I looked at many articles. I also have a son who is 15 years old, I also looked at them because he would be vaccinated. 3 doses have been in-jected. I meticulously looked at the side effects of these vaccines. What did it prevent, why do we have it? The only reason of my 15-year-old son's being vaccinated is that I didn't want him to be a carrier. He doesn't get sick, he goes to fitness every day, he's a very healthy kid.That is, I don't think he will be damaged in any way, but he could be a carrier. I wanted him to be vaccinated because I thought he could infect other people without knowing, we couldn't take that risk.

During the interviews, physicists have adopted their epistemic performance to the second issue. Hence as metacognitive elements of epistemic performance aspect 2 was observed. In the Table 4.2 you can see the example quotation of aspect 2. begingroup

Table 4.3. Metacognitive elements epistemic performance demonstrated by physics professors.

Aspect of Apt Epistemic Performance	**Example Quotation**
Aspect 2: Adapting Epistemic Performance	*Physicist A: Not wanting to be vaccinated... It's hard to say something because I'm not an expert on this subject. Maybe it should be listened their arguments. However, science isn't knowledgeable enough on a subject, it might be at first. In January 2022, sufficient data has probably been came into existence , and he sees the results of vaccination. Now he probably talks about the harmful effects/ sides of the vaccine. It (harmful side) probably can be. There is such a situation in everything. But if we put the scales, the harmful parts of being vaccinated, the vaccination will become more important.*

Physicists have demonstrated all of the cognitive elements of epistemic performance. In Table 4.4 examples to those elements are given.

Table 4.4. Cognitive elements epistemic performance demonstrated by physics professors.

Components of Epistemic Cognition	**Example Quotation**
Epistemic Aim	*Physicist B: Because as I was vaccinated, I looked at many articles. I also have a son who is 15 years old, I also looked at them because he would be vaccinated.*
Epistemic Ideal	*Physicist A: Not wanting to be vaccinated... It's hard to say something because I'm not an expert on this subject. Maybe it should be listened their arguments. However, science isn't knowledgeable enough on a subject, it might be at first. In January 2022, sufficient data has probably been came into existence*
Reliable Process	*Physicist B: Because as I was vaccinated, I looked at many articles. I also have a son who is 15 years old, I also looked at them because he would be vaccinated. 3 doses have been injected. I meticulously looked at the side effects of these vaccines. What did it prevent, why do we have it?*

4.1.3. Comparison of Physicists' Approach to Two Issues

While comparing the two issues, physicist B has focused on the measurement procedures. For the first issue, he has identified measurable and non-measurable concepts. According to him physicists are able to measure the value of cosmological constant. However he found the concept of multiverse to be non measurable. He argued physicists have meas-ured the value of cosmological constant repeatedly. By measuring

repeatedly, they have decreased percentage error.

Physicist B has thought the trustworthiness of Covid vaccines are established through sta-tistical methods. He argued the sample has to represent the population. Hence he made a clear distinction of reliable processes between disciplines [aspect 2, reliable process]:

> Physicist B: Since the things in the first video are measurable (cosmological constant), it became obvious that we will connect measurable things in physics already there. There are also things that cannot be measured. We can't connect an employee's being vaccinat-ed, that is, a doctor's not wanting being vaccinated to how scientific the multiverse model is because they are actually a little different from each other. Because I have data about the vaccine, but not about multiverse. There is a debate among the people who only inter-pret the data about the vaccine, if the data is enough or not, or it shows what or what not. Well, we measure some parameters, very sensitive values, for example that the first doc-tor said. These are measurable things, also in physics. They have been measured many times, there is an error, there is a measurement error, these are very small errors. Physi-cists have minimized them. The situation in statistical studies is slightly different. Statis-tics is a little sensitive matter. That is, why is it a sensitive issue? For example, as you can't do the measurement, statistical, experiment with 1 million people, you are doing it with 1000 people, with 1 million patients, It is necessary to select those 1000 people in such a way that they can represent that 1 million people. Their age group, how old are they, are they white or black or blond, what is their blood group? You have to choose them properly. This is a science, that is, a special field of mathematics, if you do it wrong, you will get wrong results. Do you understand what I mean? The measurements we talk about physics are not statistical studies, they are being measured though. You measure by experimenting. Experiment and observation in physics, is the basic thing. That is physi-cists don't have a statistical study like that.

4.2. Teaching Physics Students

4.2.1. Teaching Physics Students' Understandings of Physics

Teaching physics students have reflected their understandings of physics. However, those inferences mostly involved reliable processes and few epistemic ideals used in physics. Teaching physics student A has identified taking measurements through experimentation as a way of controlling an existing theory [reliable process of taking

measurements during experimentation]:

> Teaching Physics Student A: We can feel it (the universe is fine tuned) on a large scale in the universe, but I don't think we feel it right now. Maybe we can measure it experimental-ly, namely visually. Yes, it's okay but it's hard to conduct an experiment about that for now.

Teaching physics student D has argued making calculations [reliable process of making calculations] to see whether the information fits the equation or not can be used to evalu-ate a knowledge claim. She has also demonstrated an understanding formulas. She has inferred formulas are built by humans [aspect 3, metacognitive]:

> Researcher: So how can you know or why can't you know that your point of view is correct?
> Teaching Physics Student D: Can I know it's true... I mean, if the formula we are talking about for science fits, I guess it seems right, but we made that formula ourselves, maybe we did it to fit it, but I'm telling a fib, I've tried one million probabilities, Or I've tried five million possibilities and if this formula says yes to me, yes, this planet is that far away and if I am able to support it with other things like maths (calculations), I think I can trust this information.

Other processes used by teaching physics students while evaluating knowledge claims were observations [reliable process of observation], reading trusted resources [reliable process of reading from trusted resources] and synthesising previous knowledge [reliable process of synthesising previous knowledge]. They were used by teaching physics student C. However there were no indication whether the observation is at personal capacity or does it contain observation through scientific equipment as well:

> Researcher: So what is right for you? What do you mean when you say right?
> Teaching Physics Student C: True for me would be the observable. You know, sometimes trustable, that is trustable research. Sometimes it can be just my inference. So by inference, I mean trusting. For example, things like that can happen. For example, the multi-verse universe theory that popped into my mind. Maybe during my life I won't be able to see whether to prove this theory or not. But I believe. Why do I believe? For example, let's say I have some knowledge of my own. When I put them together in my mind, that way also makes sense to me. That's why, although correct information is observable, I can say that I have been able to observe, and as a result, I have reached a little bit of other knowledge.

Forming analogy [reliable process of using analogy] was another reliable process used while evaluating a knowledge claim. Teaching physics student B has formed an analogy between universe and daily life to evaluate Susskind's claim regarding constants of the universe to be at a knife edge. Daily life part of the analogy based on the observations [reliable process of observations] of the participant:

> Teaching Physics Student B: Actually, this thought made sense to me, because even a small change in the weather can cause different weather conditions. I guess that I can show this as a small analogy. In other words, even in daily life, when there is a small mishap, the course of some things actually changes. In the universe, with a small change, the course could change completely. Maybe the universe could go to extinction. So I think that there is a fine-tuned. Its existence makes sense to me.

Another reliable process was reading from the works of authorities. Teaching physics stu-dent A thought reading texts written by scientists [reliable process of reading from the experts] is a legit way of controlling the validity of a knowledge claim. In the same in-stance teaching physics student A has demonstrated and inference regarding the structure of knowledge. While talking about knowledge, she has only defined true or wrong knowledge. She believed true knowledge is the knowledge supported by the authorities: Researcher:

> So can you know if your point of view is correct? How can you know or why can't you know?
> Teaching Physics Student A: If I read the articles and studies of the scientists (experts) who made these, I can say "Yes, it is like that, even if it is at least 10%, so there is such a thing" and I can confirm my knowledge. If it is not correct, I can renew myself by saying that I was wrong, you know, I had wrong information. You know, I think that if I need to follow the studies in this field, I can know.

Teaching physics student B has used reading form the works of authorities [reliable pro-cess of reading from the experts] as a way of evaluating the validity of a knowledge claim as well. In this case the source of authority was god. In addition teaching physics student B has used relying on her experience as a reliable process [reliable process of re-lying on experience]:

> Researcher: What do you base your point of view on?
> Teaching Physics Student B: What am I basing it on?
> Researcher: So, for example, your previous experiences, science, religion or philosophy?
> Teaching Physics Student B: So as I said, I've seen something like this before. I actually thought that something like this was logical, based on the fact that it was proven. Of course, religion can also have an effect. I guess I can say that because it is written in the books.
> Researcher: By saying books, do you mean holy books? Teaching Physics Student B: Yes, I mean the holy books.

In the data of teaching physics students, criteria for a knowledge claim to be considered as true was present as well. Teaching physics student D has mentioned two criteria which a true knowledge claim must possess. Those were being universal [epistemic ideal of being universal], being calculable [epistemic ideal of being calculable] and being measurable [epistemic ideal of being measurable]. Being universal was defined as being applicable from the smallest scale to the largest scale. Hence there was an metacognitive understanding regarding the criteria for being universal [aspect 3, metacognitive]:

> Teaching Physics Student D: Well, it may be true, since I don't know the exact values, I shouldn't say anything about this video. He said this number true, I can't say its etcs. It can be true, why can it be true? As I said, if I put my constant for example in my every problem, it really gives me a result, but I say that if it is something that I can go from small to big, that is, I can measure it, that is, I can prove it in a different way. yes, then if I continue measuring using this constant this gives me a little more growth in numbers, I can say that it is correct, I determine the truth accordingly [universality of the knowledge claim] for science. I go from small to large.
> Researcher: Then what you mean by true here is that when I measure constantly, if it fits in theory , is it correct? did I understand correctly?
> Teaching Physics Student D: Yes, I tried to say that, yes, I thought of it as a formula, but it does not mean that everything is a formula, yes, yes, I think so, its being measurable and calculable [opportunity to measure or calculate the knowledge claim].

Another criteria was for answers for how universe is fine tuned. Teaching physics student D has argued the answer god was not a good one because it doesn't take an

argument for-ward [epistemic ideal of property to lead further discussion]. Physicist A has thought simi-larly as well [aspect 3, ideal]:

> Teaching Physics Student D: I think all of them are different specialisation fields, I will proceed by eliminating with physics, okay?, why are they different? The God has created cannot answer other questions, that is an acceptance and one cannot take the argument forward.

Throughout the sessions, teaching physics students have demonstrated two metacognitive elements of epistemic performance: aspect 1 and aspect 3. In Table 4.5, aspects and exam-ples from the data of teaching physics students are given.

Table 4.5. Metacognitive elements of epistemic performance demonstrated by teaching physics students.

Aspect of Apt Epistemic Performance	**Example Quotation**
Aspect 1: Cognitive Engagement in Epistemic Performance	Teaching Physics Student A: We can feel *it (the universe is fine tuned) on a large scale in the universe, but I don't think we feel it right now. Maybe we can measure it experimentally, namely visually. Yes, it's okay but it's hard to conduct an experiment about that for now.*
Aspect 3: Regulating and Understanding Epistemic Performance	*Teaching Physics Student D: I think all of them are different specialisation fields, I will proceed by eliminating with physics, okay?, why are they different? The God has created cannot answer other questions, that is an acceptance and one cannot take the argument forward.*

Teaching physics students have demonstrated two of the cognitive elements of epistemic performance. Related examples from the sessions are presented in Table 4.6.

Table 4.6. Cognitive elements of epistemic performance demonstrated by teaching physics students.

Components of Epistemic Cognition	**Example Quotation**
Epistemic Ideal	*Teaching Physics Student D: I think all of them are different specialisation fields, I will proceed by eliminating with physics, okay?, why are they different? The God has created cannot answer other questions, that is an acceptance and one cannot take the argument forward.*
Reliable Process	*Researcher: So how can you know or why can't you know that your point of view is correct? Teaching Physics Student D: Can I know it's true... I mean, if the formula we are talking about for science fits, I guess it seems right, but we made that Formula ourselves, maybe we did it to fit it, but I'm telling a fib, I've tried one million probabilities, Or I've tried five million possibilities and if this formula says yes to me, yes, this planet is that far away and if I am able to support it with other things like maths (calculations), I think I can trust this information.*

In the session of teaching physics students there were cognitive element of reliable pro-cesses different from the session of physicists. It was the reliable process of relying on experts. This element emerged in two ways: relying on scientists and relying on god. An-other reliable process was observations done at personal capacity. The related examples from the sessions have been presented in the Table 4.7:

Table 4.7. Different examples of cognitive elements of epistemic performance from teaching physics students.

Reliable Process	**Description**	**Example Quotation**
Reading from the works of experts	Scientists who work in that field	*Researcher: So can you know if your point of view is correct? How can you know or why can't you know? Teaching Physics Student A: If I read the articles and studies of the scientists (experts) who made these, I can say "Yes, it is like that, even if it is at least 10%, so there is such a thing" and I can confirm my knowledge. If it is not correct, I can renew myself by saying that I was wrong, you know, I had wrong information. You know, I think that if I need to follow the studies in this field, I can know.*
	Holy Books (God)	*Researcher: What do you base your point of view on? Teaching Physics Student B: What am I basing it on? Researcher: So, for example, your previous experiences, science, religion or philosophy? Teaching Physics Student B: So as I said, I've seen something like this before. I actually thought that something like this was logical, based on the fact that it was proven. Of course, religion can also have an effect. I guess I can say that because it is written in the books. Researcher: By saying books, do you mean holy books?Teaching Physics Student B: Yes, I mean the holy books.*
Making observations	At Personal Capacity	*Researcher: So what is right for you? What do you mean when you say right? Teaching Physics Student C: True for me would be the observable. You know, sometimes trustable, that is trustable research. Sometimes it can be just my inference. So by inference, I mean trusting. For example, things like that can happen. For example, the multiverse universe theory that popped into my mind. Maybe during my life I won't be able to see whether to prove this theory or not. But I believe. Why do I believe? For example, let's say I have some knowledge of my own. When I put them together in my mind, that way also makes sense to me. That's why, although correct information is observable, I can say that I have been able to observe, and as a result, I have reached a little bit of other knowledge.*

4.2.2. Teaching Physics Students' Understandings about Covid Vaccines

For the second issue, teaching physics students haven't used any of the reliable processes which they have demonstrated while engaging with the first issue. For example teaching physics student B has relied on her emotions [reliable process of relying on emotions] while choosing a side for the second issue. However, she had her concerns about the ethical aspects of the first doctor's decision. Hence, looking at the ethics emerged as another reliable process [reliable process of checking whether the behavior is ethical or not] in the same instance:

> Teaching Physics Student B: I can't decide who is right, right now. Actually, when I look a little emotionally, I am more close to the dismissed doctor, but when we look at the ethics of the doctor's profession, the other side seems normal, but I would still say, I think, noth-ing should be mandatory in every subject.

In another quotation, teaching physics student B has based her emotions to her personal experiences [reliable process relying on experience]:

> Researcher: So what drives you to this point of view?
> Teaching Physics Student B: Let me tell you, it was the same with the things I've seen so far. It seems to me that when you force something, it is either repulsive or you do the op-posite. If it were done to me, I think I would have resisted too. I think so, that is, the right of a person is to express his opinion, to act accordingly, to obey his own principles. I think he has that right. So I think he should have such a right.
> Researcher: What do you base your point of view on?
> Teaching Physics Student B: What am I basing it on? Can you say something as an exam-ple? Because the question sounds a bit general to me.
> Researcher: Actually, there was a similar question in the previous one too. Again, like there, it may be scientific knowledge, your own experience, religion, philosophy or some-thing else.
> Teaching Physics Student B: So I say it's my own experience. No need to force it.

Like teaching physics student B, teaching physics student A has trusted her experience while evaluating effectiveness of covid19 vaccine [reliable process of relying on experience]. She thought covid vaccine is effective because it prevented her being hospitalised when she had covid. Emphasis was more on the self than the well being of

the others. Hence, being beneficial to self has emerged as a criteria used for evaluating a decision regarding the second issue [epistemic ideal of being beneficial to the self]:

> Researcher: So how sure are you about your point of view?
> Teaching Physics Student A: So my perspective misled me by 20%. Why is that? It's what I live in my daily life that yes, I was vaccinated. I remember correctly, it was my second dose. Was may be the third dose? I am not sure. I think it was the third dose, I don't re-member it exactly. 20 days after I was vaccinated, I got corona too. Yes, you know, did it totally protect me? It didn't protect. Did I get the virus in spite of the vaccination? Yes, I did. However, what I prevented is to be hospitalised. I could be intubated. Maybe if I if I had a chronic disease, yes, I would be intubated in this period. You know, there was a time when the level of hospitalisation among young people increased here. Maybe I could be one of those young people. But the vaccine also reduced it (the risk of being hospitalised). I can also give this example from my daily life: During the one-week period of covid, I had muscle pain etc. Maybe it's because of variation. But I had a more so severe flu infec-tion that I was hospitalised. When I remembered such events, I thought maybe the vaccine protected me. Maybe antibodies were somehow created, and I can say that I got off it lightly. Namely I was afraid of getting sick. I had not caught corona for 2 years.

Teaching physics student D has argued studying the results of other's experimentations is a reliable process to know whether a point of view is correct or not regarding the second issue [reliable process of repeated experimentation]. She has also demonstrated a meta-cognitive understanding about a process of evaluating a knowledge claim [aspect 3, meta-cognitive].

> Researcher: So can you know that your point of view is correct, how can you know or not?
> Teaching Physics Student D: I mean, if I were a scientist interested in vaccines in this field, I would probably know. That is I don't know, I can't say anything about whether it is true or not, but I think that people who really work in this field, who do their experiments, who read the inputs and outputs of other people's experiments, even if they don't do it themselves, can be sure of their thoughts on this subject.

At another instance, teaching physics student D has demonstrated another metacognitive understanding [aspect 3, metacognitive] while commenting on Dr. Steve James' claim that covid doesn't kill young, fit and healthy people. Teaching physics student D has ar-gued it is easy to falsify:

> Teaching Physics Student D: If it has one exception, that falsifies it. So this means that Steve James doesn't affect the young people, but no, if the young people were affected and the young people died too, it takes him directly to the wrong side for me, so it's a very clear issue.

While making evaluations regarding the second issue, teaching physics student C has checked whether the decision will hurt people or not [epistemic ideal of not being harmful to people]. She argued the long term effects of the vaccine is not known and in the long run it has a possibility of hurting qualified people:

> Teaching Physics Student C: I still think about this. You know, you say why you endanger the people there, but after all, when you give this vaccine, you don't really talk about how big brains you will endanger. Because this, what you call a vaccine may protect you from covid, but you don't know how it will affect you in the long run.

Teaching physics student C's concern about the unknown effects of the covid vaccines in the long term was present in the data of teaching physics student D as well. She has used adequate duration of testing as a criteria [epistemic ideal of adequate duration of testing] for evaluating the research studies conducted to establish the trustworthiness of covid vaccines, thus demonstrating an metacognitive understanding regarding the testing proce-dures [aspect 3, metacognitive]:

> Teaching Physics Student D: Well, yes, we cannot. That's why I say, the x vaccine was found in 5 years, the emergence of a vaccine in such a short time may cause some prob-lems in long term, even the effect of something, a vaccine or pill, I remember one of the debates that came out at that time. I wonder if it caused infertility in children born, I don't know, it caused a change in shape and so on because I don't remember that vaccine or pill, not enough experiments were done on it, rather than experimenting, I don't know, although a drug takes that long to come out in a 10-year 20-year job, the COVID vaccine came to us in two years. When did you find it, when did you research it, when did you see its effects? Simply being a woman, when I got pregnant, when I saw its effect on my child when he was born, or as a heart patient, or how a 3-year-old child grew up, what kind of changes it caused. it was a rapid transition.

Being aware of short duration of testing of covid vaccines, teaching physics student D has sided with Dr. Hilary Jones. Apparently, she has also received covid vaccine.

She has reached her ultimate decision regarding the issue by listening to the authorities [reliable process of listening the authorities].

> Researcher: So which speaker do you agree with?
> Teaching Physics Student D: Which speaker do I agree with... I mean, as I said at the be-ginning, I also had question marks in my mind, but somehow I need to trust certain authorities, I attribute this to something: "If I have been vaccinated against measles before and this has protected me against measles." this means that vaccines are effective and I need to be vaccinated too. So who was he to the side that we should be vaccinated?
> Researcher: Dr. Hilary Jones Teaching Physics Student D: Exactly, I agree with him.
> Researcher: What drives you to this point of view?
> Teaching Physics Student D: As I said, I am saying this based on my previous experiences, I say that if a vaccine has protected me from a disease, this vaccine will also protect me from that disease, but there, as I said at first, I thought how effective can a vaccine which was found in such a short time be, but I've had my vaccinations.

Teaching physics students haven't transferred any elements from their prospective field which is physics. Hence, they haven't demonstrated aspect 2. However they have demon-strated an understanding about appropriate components of epistemic cognition within the context of the second issue. An example quotation can be seen in the Table 4.8:

Table 4.8. Metacognitive elements of epistemic performance from teaching physics students.

Aspect of Apt Epistemic Performance	**Example Quotation**
Aspect 3: Regulating and Understanding Epistemic Performance	*Researcher: So can you know that your point of view is correct, how can you know or not? Teaching Physics Student D: I mean, if I were a scientist interested in vaccines in this field, I would probably know. That is I don't know, I can't say anything about whether it is true or not, but I think that people who really work in this field, who do their experiments, who read the inputs and outputs of other people's experiments, even if they don't do it themselves, can be sure of their thoughts on this subject.*

In terms of cognitive elements of epistemic performance, there were two types encountered in the sessions of teaching physics students. Those elements and their examples are listed in the Table 4.9 below.

Table 4.9. Cognitive elements of epistemic performance from teaching physics students.

Components of Epistemic Cognition	**Example Quotation**
Epistemic Ideal	*Teaching Physics Student C: I still think about this. You know, you say why you endanger the people there, but after all, when you give this vaccine, you don't really talk about how big brains you will endanger. Because this, what you call a vaccine may protect you from covid, but you don't know how it will affect you in the long run.*
Reliable Process	*Teaching Physics Student D: If it has one exception, that falsifies it. So this means that Steve James doesn't affect the young people, but no, if the young people were affected and the young people died too, it takes him directly to the wrong side for me, so it's a very clear issue.*

Similar to the sessions conducted with teaching physics students regarding the first issue, there were cognitive element of reliable processes different from the session of physicists within the context of second issue. They were epistemic ideal of not being hospitalised due to covid and reliable processes of relying on experts and relying on emotions. The related examples from the sessions have been presented in the Table 4.10:

Table 4.10. Different examples of cognitive elements of epistemic performance from teaching physics students.

Related Cognitive Element of Epistemic Performance	**Definition**	**Example Quotation**
Epistemic Ideal	Not being hospitalised due to covid	*Teaching Physics Student A: So my perspective misled me by 20%. Why is that? It's what I live in my daily life that yes, I was vaccinated. I remember correctly, it was my second dose. Was may be the third dose? I am not sure. I think it was the third dose, I don't remember it exactly. 20 days after I was vaccinated, I got corona too. Yes, you know, did it totally protect me? It didn't protect. Did I get the virus in spite of the vaccination? Yes, I did. However, what I prevented is to be hospitalised. I could be intubated. Maybe if I if I had a chronic disease, yes, I would be intubated in this period. You know, there was a time when the level of hospitalisation among young people increased here. Maybe I could be one of those young people. But the vaccine also reduced it (the risk of being hospitalised). I can also give this example from my daily life: During the one-week period of covid, I had muscle pain etc. Maybe it's because of variation. But I had a more so severe flu infection that I was hospitalised. When I remembered such events, I thought maybe the vaccine protected me. Maybe antibodies were somehow created, and I can say that I got off it lightly. Namely I was afraid of getting sick. I had not caught corona for 2 years.*
Reliable Process	Relyign on authorities	*Researcher: What drives you to this point of view? Teaching Physics Student D: As I said, I am saying this based on my previous experiences, I say that if a vaccine has protected me from a disease, this vaccine will also protect me from that disease, but there, as I said at first, I thought how effective can a vaccine which was found in such a short time be, but I've had my vaccinations.*
	Relying on emotions	*Teaching Physics Student B: I can't decide who is right, right now. Actually, when I look a little emotionally, I am more close to the dismissed doctor, but when we look at the ethics of the doctor's profession, the other side seems normal, but I would still say, I think, nothing should be mandatory in every subject.*

4.2.3. Comparison of Teaching Physics Students' Approach to Two Issues

While comparing the two issues, teaching physics student B has believed the second issue is a part of daily life while the first one is not. Hence, while choosing a side for the second issue, she has based her decision to her emotions. This reflects the contextual aspect of epistemic performance. As the issue became related with daily life, the approach of the participant has changed:

> Researcher: Well, when choosing a side on these two issues, what kind of differences were there for you due to the nature of the issues?
> Teaching Physics Student B: I can say that I look at the second video a little more emo-tionally. So yes, there was a difference in that way.
> Researcher: So why did this happen?
> Teaching Physics Student B: Why did it happen? Maybe because it was from real life, it was more updated, it was lived. After all, I looked a little more emotional because some-thing like this happened to me. But examining physical events, interpreting them, comparing them, etc. was not something I did every day. That's why I looked at this subject a little more emotionally.

A similar thought was present in the session of teaching student A as well. She too be-lieved the second issue was more related with daily life. Hence, her demonstrated epis-temic performance differed significantly in terms of metacognitive elements of epis-temic performance (aspects of apt epistemic performance) accordingly. She admitted due to the weakness of her knowledge in physics, she had to infer her prior knowledge and sensa-tions. Hence, when weakness in knowledge is present [aspect 2, adapting epistemic per-formance (according to constraints)], making inferences on prior knowledge and sensa-tions [reliable process of making inferences on prior knowledge and sensations] was de-tected as a reliable process:

> Researcher: So, when choosing a side on these 2 issues, what are the differences for you resulted from the nature of these issues?
> Teaching Physics Student A: I have embraced the more daily event, the covid event. Be-cause from a more logical perspective, it is a process that I live. Otherwise, I was a bit weak in terms of knowledge in my field. I just felt the need to make an inference from my general knowledge and sensations. I can say that there is this kind of difference.

On the other hand, teaching physics student D has preferred to see similarities between the issues. She argued experimentation and calculations were common reliable process used to generate or test knowledge claims regarding the both issues. However, unlike physicists, teaching physics student D has not explained any criteria for experimentations or calculations, thus did not demonstrate a metacognitive understanding about any aspect of apt epistemic performance:

> Teaching Physics Student D: I understood, so how could they have obtained the things in the videos, I want to believe both sides, especially the COVID side. I want to believe that they came up with experiments, I mean, they came up with experiments to reduce the risk of transmission of the vaccine, here they are, in order to find the fine-tuning in order to be able to do something, and in order for them to come to a certain order with a certain or-der of things and probabilities, they observed them, they did an experiment, so yes, this possibility is an experiment. I think that both of the math claims can be revealed by experiment.

4.3. Data From Social Students

4.3.1. Nature of Physics from the Eyes of the Social Sciences Students

During their sessions, social sciences students have demonstrated understandings regard-ing discipline of physics. Like physicists, social science student D has thought the first issue is outside of physics. He has made a distinction between scientific and non-scientific knowledge. Hence he has demonstrated an understanding regarding what physics include [aspect 3, metacognitive]:

> Social Sciences Student D: Here, for example, there is a belief because it is a matter of God and religion. I mean, these people have faith other than physics. That's a little out-side the realm of physics. It's about people's personal feelings. For example, if you have a belief in a religion, this may increase the probability of attributing the cause of some events, such as the combination of possibilities in this universe, to that creator. Or, like-wise, if my religious belief is weak, I may be less likely to attribute it there. As this subject is a bit of an emotional, social, sociological, religious etc. issue apart from physics, that is it has fields other than positive science, people's thoughts can evolve in this way.

Social sciences student A has made a similar remark as well. During the first video Suss-kind uses a phrase "who ever made the universe". When social sciences student A has heard that phrase, she thought the issue drifted away from physics. Hence social sciences student A has demonstrated aspect 1 of identifying epistemically valuable products (in the discipline of physics) to aim for:

> Susskind: Physicists make a habit of using the phrase "whoever created the universe," but they don't actually mean it in that sense. But whoever created the universe created it with an incredibly small cosmological constant.
> Social Sciences Student A: He claims to have created it with a small force. So it makes sense, considering that it took millions of years for the universe to take its current form. It pulls a bit to a social side.

During the interview sessions, social sciences student C has defined a scale of ten. In the scale, one referred to not certain at all and ten referred to completely certain. At some point, she has rated her certainty about her tendency regarding the issue 1, 8 out of 10. While talking about the rationale behind her decision, she has demonstrated various infer-ences about physics and mathematics. First, she argued mathematics is based on humans' assumptions. Therefore she thought it might be wrong. Then, she has talked about physics. She argued in physics, for a knowledge claim to be to be true, it has to be tested repeated-ly [reliable process of testing repeatedly]. She also claimed it would take only one exper-iment to refute a knowledge claim [reliable process of refuting a knowledge claim]. She emphasised there is always a possibility of mathematics being wrong, since it is a human construct. She explained that's why she can never give her certainty 10 out 10. Hence social sciences student C has demonstrated a metacognitive understanding similar to the physicist B regarding mathematics and physics by acknowledging there are no absolute truths [aspect 3, metacognitive]. Lastly, she demonstrated a reliance on authorities [relia-ble process of relying on authorities]. For this quantitation those authorities were mathe-maticians and physicists:

> Researcher: For example, you said that some things based on experimentation, there is mathematics behind it, they support it that way, but you gave 8 out of 10 for its correctness. What do you think is the reason for that two-point difference?
> Social Sciences Student C: Because 1- mathematics is a science, yes, but in the

> end, mathematics is based on our (humans') most basic assumptions. After all, we decide that 1+1 is 2 in the structure we set up, that is our mathematics may also be wrong. So I can't be sure. Secondly (this probably has a terminology, but) you may need to do millions of experiments to prove if something is true, but one experiment is enough to refute it, we have much less trials and arguments with this calculation than it should be, and we have to try hard on it. So I would not give 10, I would give 7-8 for these two reasons: 1) the methods we use may also be wrong, 2) because much more data is needed. And as I said, I don't think we can achieve this, so maybe I could give lower than 7, as I don't know much about the field, I trust mathematicians and physicists a lot.

Apart from how produce or evaluate scientific knowledge, social sciences students had also presented criteria for scientific knowledge. In one instance, social sciences student A has made distinction between a scientific knowledge claim and non-scientific knowledge claim. According to her a scientific knowledge has to be testable and its trustworthiness has to be tested repeatedly [epistemic ideal of being testable and tested repeatedly ; aspect 1]:

> Researcher: Well, while watching the video, you actually said something, you matched physics with scientific knowledge at the beginning of the video. For example, what distin-guishes the claim of scientific knowledge from the claim of non-scientific knowledge for you?
> Social Sciences Student A: It's being more testable for me. And in every way its accuracy's being seen again and again.

Another criteria was presented by social sciences student D. He has identified criteria for reliable knowledge in physics. According to him, in physics knowledge which has not been falsified, is able to solve the most number of problems and accepted by the authori-ties can be regarded as the most reliable knowledge [epistemic ideal of not being wronged and ability to solve the most number of problems]. Also, there was relying on authorities in the same instance provided by social sciences student D [reliable process of relying on authorities]:

> Researcher: In your opinion, what are the criteria and conditions that make it the most accurate information for now?
> Social Sciences Student D: Like this. If I need to give an example in the field of physics, the information accepted by the authorities on this subject, which has not been falsified, is valid in the most fields, and can solve most of our problems, can be described as the most accurate. In other words, when new information

> can solve more problems and is more accepted, we can take our new truth as that, if it is more correct.

In Table 4.10 examples of aspects of metacognitive elements of epistemic performance by social sciences students can be seen:

Table 4.11. Metacognitive elements of epistemic performance demonstrated by teaching physics students.

Aspect of Apt Epistemic Performance	**Example Quotation**
Aspect 1: Cognitive Engagement in Epistemic Performance	*Social Sciences Student D: Here, for example, there is a belief because it is a matter of God and religion. I mean, these people have faith other than physics. That's a little outside the realm of physics. It's about people's personal feelings. For example, if you have a belief in a religion, this may increase the probability of attributing the cause of some events, such as the combination of possibilities in this universe, to that creator. Or, likewise, if my religious belief is weak, I may be less likely to attribute it there. As this subject is a bit of an emotional, social, sociological, religious etc. issue apart from physics, that is it has fields other than positive science, people's thoughts can evolve in this way.*
Aspect 3: Regulating and Understanding Epistemic Performance	*Researcher: Well, while watching the video, you actually said something, you matched physics with scientific knowledge at the beginning of the video. For example, what distinguishes the claim of scientific knowledge from the claim of non-scientific knowledge for you? Social Sciences Student A: It's being more testable for me. And in every way its accuracy's being seen again and again.*

Social sciences students have demonstrated two of the cognitive elements of epistemic performance. The short definitions and related examples from the sessions are presented in Table 4.12.

Table 4.12. Cognitive elements of epistemic performance demonstrated by social sciences students.

Components of Epistemic Cognition	**Example Quotation**
Epistemic Ideal	*Researcher: Well, while watching the video, you actually said something, you matched physics with scientific knowledge at the beginning of the video. For example, what distinguishes the claim of scientific knowledge from the claim of non-scientific knowledge for you?* *Social Sciences Student A: It's being more testable for me. And in every way its accuracy's being seen again and again.*
Reliable Process	*Social Sciences Student* C: You may need to do millions of experiments to prove if something is true, but one experiment is enough to refute it

There were cognitive element of reliable processes different from the session of physicists within the context of first issue for social sciences students. It was the reliable processes of relying on authorities. The related example from the sessions have been presented in the Table **??**:

Table 4.13. Different examples of cognitive elements of epistemic performance from teaching physics students.

Components of Epistemic Cognition	**Definition**	**Example Quotation**
Reliable Process	Relying on authorities	*Social Sciences Student C: 1) the methods we use may also be wrong, 2) because much more data is needed. And as I said, I don't think we can achieve this, so maybe I could give lower than 7, as I don't know much about the field, I trust mathematicians and physicists a lot.*

4.3.2. Mandatory Covid19 Vaccine: For the Greater Good

Three out of four social sciences students have sided with the doctor who advocates covid19 vaccine must be mandatory to healthcare workers who are in direct contact with patients. The common criteria used by the three social sciences students were the decision not being harmful to other people [epistemic ideal of not being harmful to society]:

> Social sciences student A: I agree with Hilary Jones, because it didn't happen until now, as he also stated, since he developed antibodies, he probably got into her body and car-ried it. He put patients at risk. What kind of Hippocratic oath is this?
> Researcher: So what do you base your point of view on?
> Social sciences student A: Because he doesn't get covid vaccine, what he undertakes as a doctor is to serve patients, and at the same time, he should not cause

> any diseases. One thing that makes this easier is the vaccine. He is someone who didn't protect himself and those around him, has put others at risk by not vaccinating himself, and put the patients around him at risk.

The same criteria was evident in the data of social sciences student B [epistemic ideal of not being harmful to society] as well. Social sciences student B has admitted she has ap-proached the topics differently. For the first issue, she has considered only her beliefs. But in the second one, she has considered the well being of the society. Social sciences stu-dent B has thought the second issue was more involved with society. She later identified this feature as the main driving force which affects her way of making decisions. She ad-justed her epistemic cognition while talking about the issues. This an indication for aspect 2 [aspect 2, adapting epistemic performance]:

> Social Sciences Student B: I think, one of them was more individualistic, the first subject about physics. That was the thing, not believing in something. "Do you think so or not?". But the second one was a bit about society, there was something clear about the society, Whether or not vaccination is mandatory is something that can directly affect people's lives, whether they survive or not. While deciding, for the second one I made a decision by thinking of other people as well because this is something that should be done considering the general well-being of not only individuals but society as a whole, if we live in a socie-ty together. But the other one is a more individual belief and a more individual idea, that is, whether there is a "fine-tuning" of the universe or not. He may not cure the disease of someone who has COVID, or may not cause their disease to progress, but he may be stat-ing such an opinion about it. It just seemed to me something more individual.

Similarly, while talking about the second issue, social sciences student C has sided with Dr. Hilary Jones. She has checked whether her decision harms other people or not. Hence she has used being not harmful to people as a criteria [epistemic ideal of not being harm-ful to society]. This has emerged as an epistemic ideal. Being not harmful to people was associated with the Hippocratic oath. The oath is taken by doctors. Hence, social sciences student C has thought being not harmful to society as an epis-temic ideal because the sub-ject was a doctor. This was a clear adaption of epistemic performance according to a con-straint [aspect 2, adapting epistemic performance] :

> Researcher: Now what do you think of the information claims presented in the video re-garding healthcare professionals who are in direct contact with patients?
> Social Sciences Student C: Well, for example, you work in a nuclear reactor. You have certain responsibilities to protect yourself from the nuclear waste there and not to carry it out of that place. And isn't there any serious protection about clothing etc.? Okay, may-be that guy doesn't want to wear that costume either, but at the end of the day, when it affects people other than you, I think it's not personal liberty. There is also the Hippocrat-ic oath, people have sworn to protect people. That's why I think that they accept them by being in this health sector. At the end of the day, when you can influence people other than yourself, in which case there is possibility of doctors turning into incubators as I and doctors said in the video... When you can influence others, you don't have that much per-sonal freedom. That's why I think the second speaking and supporting man makes more sense, but frankly, as I said at the beginning of the video, I was thinking the same before watching this video. That's why I didn't make a comment like "Oh, he's so right", frankly.

In parallel with her previous attitude, social sciences student C has emphasised being not harmful to other people [epistemic ideal of not being harmful to society] in another in-stance. She has identified looking from a general perspectives in issues such as the covid vaccine is a must for politicians and experts. Because they have duty to protect the greater good. By explaining why being not harmful to society is an important epistemic ideal, she has demonstrated an ability to identify appropriate epistemic ideals [aspect 1, cognitive engagement in epistemic performance]:

> Researcher: So why did you think it was a vicious argument to expect this to be one hun-dred percent true?
> Social Sciences Student C: Well, I know I said the same thing in the first video, but now let's think about the pandemic, 2020. What happened, everyone was closed, the demand for everything fell unbelievably, the economy was declining, on the one hand, there was political unrest. There was a very serious problem in the world and I have looked at the CPI indices, right now we are heading towards a much worse economic crisis than the Arab Spring, we are heading for a worse crisis than the 2008 crisis. There are other rea-sons for this, yes, but one of the most important reasons is the pandemic. And you need to look at the following: There are two options that can do harm, for example, one is not trusting this vaccine, I did not vaccinate at all, I released it to the meadow, to live in a world of goodwill, and the other is a vaccine that is not one hundred percent guaran-teed, its application is searched but it is still one hundred percent unknown. But its risk is tak-en. Okay, we are taking a risk here related to our health. I don't know, I'm vaccinated, maybe I'll be infertile, I don't know. But I mean, while studying social studies one of the things I like most is learning to look at things aggregately. You don't have to look individ-ually. Individually okay, I'm thinking about my health, but when you make a macro policy from above, you need to

> look a little more aggregate. That's why it's very short for a man to make such a decision considering only his personal health, because you have to look at the general course a little bit when you are a politician or an expert. Because that's your business. You need to maximize aggregate welfare. So it's a false argument, a multilateral argument, a vicious argument.
> Researcher: So what pushes you to your current perspective on the topic presented in the video?
> Social Sciences Student C: First of all, in my thoughts before the video, I said it clearly that it would not be very scientific. But as I said, I was thinking like that before too. The surgery example pissed me off because it's not the same thing. If you want, have your leg cut off, if you want, don't. I will go on with my life. But your lack of vaccination will affect everything. Frankly, I can say that it is easier to believe what I want to believe because I came with these thoughts, that is, I can answer with my previous thoughts.

On the other hand, social sciences student D has avoided choosing a side regarding the second issue. In spite of his avoidance, consideration of well being of the society was pre-sent in his arguments. Hence considering the well being of others have emerged as one of the criteria used by social sciences student D [epistemic ideal of not being harmful to so-ciety]:

> Social Sciences Student D: But here, an illogical part caught my eye. Now the disease and vaccine have nothing to do with the lethality of humans or whether it harms them or not. In other words, the fact that if he gets this disease, he will get over it slightly, does not change the fact that he will infect others. In fact, since the vaccine has a role to reduce and prevent contagiousness that is it has a social role, he reacts against it.

There were other examples where criteria not being harmful to other people [epistemic ideal of not being harmful to society] present in the data of social sciences student C. In another instance, she has made an analogy between the second issue and the field of eco-nomics. To do so, she has adapted her expertise from economics into the second issue. Hence, she has demonstrated aspect 2. While adapting it, she has demonstrated a meta-cognitive understanding of epistemic performance [aspect 3, metacognitive] when ex-plaining why there is a need to look at the greater picture [reliable process of looking at the greater picture] while making decision regarding the second issue:

> Researcher: So what do you base your current point of view on?
> Social Sciences Student C: Well, I want to give an example from another place. I am a graduate of economics. Having a bachelor's degree in economics has a great perspective. For example, what do you do when there is an economic crisis, when there is inflation? You raise taxes, you raise interests, right? What is he doing? He shrinks the economy, slows the economy and fights inflation. But when you look at it from an aggregate point of view, this is the right move. But when you look at it individually, you make it more diffi-cult by putting a round of taxes on the life of a person whose pocket has already become smaller due to inflation and whose life is difficult, by reducing your spending on him. So when you look at it from an individual point of view, you inflict more pain on someone who is suffering. You lower their living standards even more, but in the long run, when you look at it as a generation, as a country, that move is the right move in terms of macro-economics. When you put this case here, okay, maybe this vaccine can not be guaranteed one hundred percent in such a short time... It may have side effects, it may hurt someone, but when you look at it from a macro perspective, this is the right move in terms of econ-omy, politics and health. Maybe it is something like the best of the bad, but you need to look at it socially, not individually. That is you need to look at it aggregately, not individ-ually. People evaluate it from this point of view. Maybe it's because not everyone has studied social sciences, but I think you're making such biased arguments when you don't learn to put aside such an individualistic view. That's where it comes from, that's my opin-ion.

Social sciences student A has chosen the side of Dr. Hillary Jones (the doctor who advo-cates the mandatory covid vaccine for national healthcare staff who has a direct contact with patients) regarding the second issue. Similar to social sciences student C, social sci-ences student A has also made analogy [reliable process of forming analogies]. The anal-ogy was between the second issue and a case of a teacher who has been consuming only organic products for years. Similar to the case of Dr. Steve James, the teacher has also encountered with mandatory covid vaccine.

> Social sciences student A: "I am a healthy young man. I am not old." I think these causes are not important enough. In one of the cases we examined, a woman's lifestyle is com-pletely organic, and she never injects a fabricated drug into her body. She lives that way and doesn't want to be vaccinated. She says we will not be vaccinated, but she can lose her job. This woman is a classroom teacher. She has done her job all year, loves her job and is in danger of losing her job because of this. This is a powerful thing. This is a situa-tion that affects people's thinking and life styles in general. Because if that woman is vac-cinated, she may be affected psychologically and physiologically in a wrong way. Psycho-logically because it already disrupts her lifestyle. Physiologically, she hasn't put chemi-cals in her body for years. Perhaps there may be a complication entirely seen only in her. In this man, the presence or absence of anything will not cause

any change in his psychol-ogy, physiology, or quality of his life.

Another criteria used by social sciences students to evaluate the conclusions regarding the second issue. Social sciences student A believed if there wasn't enough data, the Covid vaccines wouldn't be so widely used. Hence, she used being in use a criteria for evaluating the trustworthiness of the vaccines [epistemic ideal of being widely used]. Ac-cording to social sciences student A benefit of the vaccines were proved by general re-searchers. So doing research has emerged as a reliable process [reliable process of doing research]. However, there no emphasis on the characteristic s of the research:

> Social sciences student A: I don't know if all the studies on the vaccine have been com-pleted or not now. But of course, it's natural for everyone to have worries about this sub-ject, but it's proven to be beneficial. In other words, I think its general researches were done and if it was thought to cause great harm to such a large group worldwide, it would not be reflected, given, or used.

In terms of reliable process, social sciences student B thought it is possible to reach a con-clusion regarding the second issue by looking into data [reliable process of looking into data]. She has used that process for acknowledging the covid vaccine makes covid virus less likely to spread:

> Social Sciences Student B: First of all, healthcare professionals are more exposed to the coronavirus because of their jobs, and I think. when they are exposed to it, there is a high probability of spreading it to other people, both within the hospital and in their personal lives. And while talking Hilary Jones mentioned that the vaccine reduces the spreading time of this virus. If the vaccine really provides such data, I don't know what the source of the data it says is, but if it's really true, this is a very important detail. I think such a thing is a serious risk, especially for doctors working with corona patients, and this is my main motivation. Even if doctors catch the virus from patients, it is a wish to prevent them from spreading it to more people.

In the second video, Dr. Steve James has argued that he hasn't seen anyone who is fit and young died of covid. Social sciences student C thought this as a unre-liable process [unre-liable process of making generalisations] to reach a well justified conclusion:

> Social Sciences Student C: Lately, he said "I haven't seen any young people who has died from covid". And I said, how haven't you seen it, for God's sake? You're not seeing it doesn't mean that it doesn't exist.

In conclusion, social sciences students demonstrated aspect 2. In Table 4.14, an example quotation from the sessions is given:

Table 4.14. Epistemic performance elements of social sciences students.

Aspect of Apt Epistemic Performance	**Example Quotation**
Aspect 1: Cognitive Engagement in Epistemic Performance	*Researcher: So why did you think it was a vicious argument to expect this to be one hundred percent true? Social Sciences Student C: Well, I know I said the same thing in the first video, but now let's think about the pandemic, 2020. What happened, everyone was closed, the demand for everything fell unbelievably, the economy was declining, on the one hand, there was political unrest. There was a very serious problem in the world and I have looked at the CPI indices, right now we are heading towards a much worse economic crisis than the Arab Spring, we are heading for a worse crisis than the 2008 crisis. There are other reasons for this, yes, but one of the most important reasons is the pandemic. And you need to look at the following: There are two options that can do harm, for example, one is not trusting this vaccine, I did not vaccinate at all, I released it to the meadow, to live in a world of goodwill, and the other is a vaccine that is not one hundred percent guaranteed, its application is searched but it is still one hundred percent unknown. But its risk is taken. Okay, we are taking a risk here related to our health. I don't know, I'm vaccinated, maybe I'll be infertile, I don't know. But I mean, while studying social studies one of the things I like most is learning to look at things aggregately. You don't have to look individually. Individually okay, I'm thinking about my health, but when you make a macro policy from above, you need to look a little more aggregate. That's why it's very short for a man to make such a decision considering only his personal health, because you have to look at the general course a little bit when you are a politician or an expert. Because that's your business. You need to maximize aggregate welfare. So it's a false argument, a multilateral argument, a vicious argument.*

Table 4.14. Epistemic performance elements of social sciences students. (cont.)

Aspect of Apt Epistemic Performance	**Example Quotation**
Aspect 2: Adapting Epistemic Performance	*Researcher: So what do you base your current point of view on?Social Sciences Student C: Well, I want to give an example from another place. I am a graduate of economics. Having a bachelor's degree in economics has a great perspective. For example, what do you do when there is an economic crisis, when there is inflation? You raise taxes, you raise interests, right? What is he doing? He shrinks the economy, slows the economy and fights inflation. But when you look at it from an aggregate point of view, this is the right move. But when you look at it individually, you make it more difficult by putting a round of taxes on the life of a person whose pocket has already become smaller due to inflation and whose life is difficult, by reducing your spending on him. So when you look at it from an individual point of view, you inflict more pain on someone who is suffering. You lower their living standards even more, but in the long run, when you look at it as a generation, as a country, that move is the right move in terms of macroeconomics. When you put this case here, okay, maybe this vaccine can not be guaranteed one hundred percent in such a short time... It may have side effects, it may hurt someone, but when you look at it from a macro perspective, this is the right move in terms of economy, politics and health.*

Table 4.14. Epistemic performance elements of social sciences students. (cont.)

Aspect of Apt Epistemic Performance	**Example Quotation**
Aspect 3: Regulating and Understanding Epistemic Performance	*Researcher: So what do you base your current point of view on?Social Sciences Student C: Well, I want to give an example from another place. I am a graduate of economics. Having a bachelor's degree in economics has a great perspective. For example, what do you do when there is an economic crisis, when there is inflation? You raise taxes, you raise interests, right? What is he doing? He shrinks the economy, slows the economy and fights inflation. But when you look at it from an aggregate point of view, this is the right move. But when you look at it individually, you make it more difficult by putting a round of taxes on the life of a person whose pocket has already become smaller due to inflation and whose life is difficult, by reducing your spending on him. So when you look at it from an individual point of view, you inflict more pain on someone who is suffering. You lower their living standards even more, but in the long run, when you look at it as a generation, as a country, that move is the right move in terms of macroeconomics. When you put this case here, okay, maybe this vaccine can not be guaranteed one hundred percent in such a short time... It may have side effects, it may hurt someone, but when you look at it from a macro perspective, this is the right move in terms of economy, politics and health. Maybe it is something like the best of the bad, but you need to look at it socially, not individually. That is you need to look at it aggregately, not individually. People evaluate it from this point of view. Maybe it's because not everyone has studied social sciences, but I think you're making such biased arguments whe you don'tn learn to put aside such an individualistic view. That's where it comes from, that's my opinion.*

In terms of cognitive elements of epistemic performance, social sciences students has demonstrated reliable process. It has emerged as reliable process looking into data. Ex-ample quotations have been given in the Table 4.15:

Table 4.15. Cognitive elements of epistemic performance demonstrated by social sciences students.

Components of Epistemic Cognition	Example Quotation
Reliable Process	*Social Sciences Student B: First of all, healthcare professionals are more exposed to the coronavirus because of their jobs, and I think. when they are exposed to it, there is a high probability of spreading it to other people, both within the hospital and in their personal lives. And while talking Hilary Jones mentioned that the vaccine reduces the spreading time of this virus. If the vaccine really provides such data, I don't know what the source of the data it says is, but if it's really true, this is a very important detail.*

There were other cognitive elements of epistemic performance different from the physi-cists' in the session of social sciences students. Those elements and related quotations are given in the Table 4.16 below.

Table 4.16. Different examples of cognitive elements of epistemic performance from social sciences students.

Components of Epistemic Cognition	**Definition**	**Related Quotation**
Unreliable Process	Speaking at personal capacity	*Social Sciences Student C: Lately, he said "I haven't seen any young people who has died from covid". And I said, how haven't you seen it, for God's sake? You're not seeing it doesn't mean that it doesn't exist.*
Epistemic ideal	Criteria of being widely used	*Social sciences student A: I don't know if all the studies on the vaccine have been completed or not now. But of course, it's natural for everyone to have worries about this subject, but it's proven to be beneficial. In other words, I think its general researches were done and if it was thought to cause great harm to such a large group worldwide, it would not be reflected, given, or used.*

4.3.3. Comparison of Social Sciences Students' Approach to Two Issues

While comparing the knowledge claims from both issues, social sciences student B has used the term "solid". Later, she has stated being solid is related with being observable. Hence being observable was perceived as a criteria for a knowledge claim [epistemic ide-al of being observable]:

> Social Sciences Student B: I think physics is a little more theoretical. Because we are not likely to say that we have done an experiment and said that we have found the result of an experiment about all possible universe variants, that is, how much it expands, how it hap-pens, etc. I'm not saying it's wrong because it's theoretical, but it's still theoretical. But I think the results of the researches on COVID are more practical, I think we can say that they are more "solid" because they are based on the experiments and the results obtained from these experiments.
> Researcher: So you associate being "solid" to experimental studies then?
> Social Sciences Student B: I really associate it to the direct observations we can make about it. Theoretically, rather than saying that if this is so, then this is so, I associate it a little on whether we have seen or observed this clearly.

4.4. Comparison Among Three Groups

In this part of chapter four, a comparison in terms of demonstrated types of elements of epistemic performance has been made.

4.4.1. For the First Issue

While talking about the first issue, physicists demonstrated 4 out of 5 aspects of apt epis-temic performance. The only aspect not demonstrated by physicists was aspect 4 - caring about and enjoying epistemic performance. This number was 2 out of 5 for teaching phys-ics students and social sciences students. Both groups have demonstrated aspect 1 - cogni-tive engagement in epistemic performance and aspect 3 - regulating and understanding epistemic performance. The common aspects demonstrated by all three groups were as-pects 1 and 3. Those findings are presented in Table 4.7.

Table 4.17. Types of demonstrated aspects for each groups within the context of the first issue.

	Physicists	**Teaching Physics Students**	**Social Sciences Students**
Aspect 1	+	+	+
Aspect 2	+	-	-
Aspect 3	+	+	+
Aspect 4	-	-	-
Aspect 5	+	-	-

In terms of cognitive elements of epistemic performance, physicists have demonstrated all three types. Teaching physics students and social sciences students have not demonstrated epistemic aims. Demonstrating epistemic ideal and reliable process were common for all three groups. Those findings are presented in Table 4.18.

Table 4.18. Types of demonstrated cognitive elements for each groups within the context of the first issue.

	Physicists	**Teaching Physics Students**	**Social Sciences Students**
Epistemic Aims	+	-	-
Epistemic ideal	+	+	+
Reliable Process	+	+	+

4.4.2. For the Second Issue

While talking about the second issue, physicists demonstrated 1 out of 5 aspects of apt epistemic performance. The only aspect not demonstrated by physicists was aspect 2 - adapting epistemic performance. This number was 1 out of 5 for teaching physics students and 3 out of 5 for social sciences students. Teaching physics students have only

demon-strated aspect 3 - regulating and understanding epistemic performance. Social sciences students have demonstrated 3 out of 5 aspects. Those are aspect 1 - cognitive engagement in epistemic performance, aspect 2 - adapting epistemic performance and aspect 3 - regu-lating and understanding epistemic performance. There were no common aspects demon-strated by the three groups. Those findings are presented in Table 4.19.

Table 4.19. Sample table Types of demonstrated aspects for each groups within the context of the second issue.

	Physicists	**Teaching Physics Students**	**Social Sciences Students**
Aspect 1	-	-	+
Aspect 2	+	-	+
Aspect 3	-	+	+
Aspect 4	-	-	-
Aspect 5	-	-	-

In terms of cognitive elements of epistemic performance, physicists have demonstrated all three types. Teaching physics students have not demonstrated epistemic aims. Social sci-ences students have only demonstrated reliable process. Demonstrating reliable process was common for all three groups. Those findings are presented in Table 4.20.

Table 4.20. Types of demonstrated cognitive elements for each groups within the context of the second issue.

	Physicists Physics	**Teaching Sciences Students**	**Social Students**
Epistemic Aims	+	-	-
Epistemic ideal	+	+	-
Reliable Process	+	+	+

5. DISCUSSION

5.1. Addressing the Research Questions

The purpose of the study was to investigate epistemic performance of physicists, preserv-ice physics teachers and social sciences students through cognitive and metacognitive elements in different task contexts. In this section, the research questions are addressed.

The first research question was: What are the cognitive and metacognitive elements of epistemic performance demonstrated by physics professors (physicists) when engaging in a controversial physics issue and a socio scientific issue?

The physicists were included in the study to establish a baseline. Because they are already physics professors and received their PhD degree in the field of physics, it was assumed their epistemic performance demonstrated within the context of the first issue is apt. As expected, physicists have demonstrated various metacognitive and cognitive elements of epistemic performance regarding the discipline of physics while engaging in with the is-sue of fine tuning. They both identified unimportant questions to investigate in physics. Ability to identify important and unimportant questions is considered to be an example for aspect 3 (Barzilai & Chinn, 2018). Both physicists thought experimentation and ob-servation is a process which leads to reliable knowledge claims in physics. Their ability to identify epistemic processes which leads to successful epistemic aims (producing or eval-uating knowledge) is an example to aspect 3. Physicist B has argued, the experiments have to repeatable by other scientist. By acknowledging evaluation of knowledge claims takes place in social configurations, he demonstrated aspect 5. According to physicists to conduct an experiment on a knowledge claim, it has to be testable. Hence, to be testable is an epistemic ideal. Ability to choose appropriate epistemic ideal is an implication for aspect 1. Physicist A thought there are good scientific theories and bad scientific theories. According to

him, a good theory is a simple one and its connections with predecessor the-ories has to be strong. But the ultimate criteria for a good theory is the theory has to work and the working has to be observed via experiments. Hence an epistemic ideal for evalu-ating a scientific theory has been demonstrated by physicist A. He also thought a scien-tific argument has to lead to further discussion. He argued otherwise the argument would a matter of belief not science. Hence, he found two of Susskind's explanations on how universe is fine tuned, god and accident unscientific since they do not lead to further dis-cussion. In here there is an understanding why the criteria of leading further discussion is an important ideal [to distinguish belief from science]. This is associated with aspect 3. In the data of physicists only one aspect of apt epistemic performance was absent. That is aspect 4 - caring and enjoying epistemic performance. Aspect 4 emphasises motivational dispositions such as curiosity, wonder, love of truth and intellectual responsibility. Con-sidering the types and the demonstration frequencies of aspects of apt epistemic perfor-mances, it can be concluded there were no significant variance between the epistemic performance of physicists.

While engaging with the mandatory covid vaccine issue, both physicists have sought data to test the trustworthiness of the covid vaccine just as they would do while engaging in a physics problem. Hence, they have adapted their epistemic performances according to the context. This is related with aspect 2.

The second research question: What are the cognitive and metacognitive elements of epistemic performance demonstrated by teaching physics students when engaging in a controversial physics issue and a socio scientific issue?

Similar to physicists, teaching physics student A has thought of experimentation as a way of producing knowledge. Hence, she has demonstrated a behaviour related with aspect 3. Another reliable process was doing calculation. According to teaching physics student A, reading the works of scientists was a way of controlling her own point of view. Hence it can be regarded as s reliable process. Regarding the second issue, teaching physics student A has evaluated Dr. Steve James' behaviour whether

he behaves ethically or not. She has defined behaving not risking other people's life as ethical. Teaching physics student B used behaving ethical as a criteria, in other words as an epistemic ideal. In the later part of her session, she has used her personal experience as a reliable process in order to reach a well grounded argument. While comparing the both issues, teaching physics student believed calculations were at the center of the first issue. However for the second one, she didn't do any calculation. Instead she has trusted in her own experience without transferring any expertise from her prospective field. Hence, she hasn't demonstrated the aspect 2.

Teaching physics student B has used her personal experience as a reliable process while evaluating knowledge claims related with fine tuned universe. Another reliable process was to relying on authorities. Authorities came in two forms: holy book (god) and experts (scientists). For a physics related knowledge claim, she had three truth criteria. Those were knowledge claim can be observed, knowledge claim can be used and knowledge claim can be supported by calculation. They can considered as epistemic ideals. While choosing a point of view for the second issue, she has employed her emotions as a reliable process. While comparing the ways she has chosen for both issues, she has said for the second issue she has trusted in her emotions. Teaching physics student D has emphasises that the experiment has to be repeatable. Hence she has demonstrated an understanding about reliable process of experimentation which counts as an evidence to aspect 3. There were no transfer of expertise from her prospective field. Hence like teaching physics student A, there were no signs of aspect 2.

While engaging with the first issue, teaching physics students have demonstrated aspects of apt epistemic performance less frequently compared to physicists. Being an undergrad might be the reason for it. Because this means they were not much acquainted with physics compared to the physicists. Even though they have named reliable processes of making calculations and experimentations while engaging in the first issue, they have not adapted those processes to the second issue. The most commonly used process by teaching physics students while engaging with the second issue was relying on emotions. In Apt-AIR framework, aspect 4 is related with emotions (Green

et al., 2021). However those emotions include curiosity, wonder, love of truth, etc. On the other hand, the emotion employed by the teaching physics students was empathy. In the study of Greene *et al.*, (2021), the experts did not provide that emotion. Furthermore, empathy was not present in the data of physicists either. Hence, presence of it can not be considered as an implication for apt epistemic performance. While engaging with the first issue, one the teaching physics students has relied upon holy books to evaluate claims presented by Susskind. One physicists has identified thinking god created the universe was as a belief rather than practicing science. Hence, while engaging with both issues, teaching physics students have adapted some unscientific approaches.

The Third research question: What are the cognitive and metacognitive elements of epistemic performance demonstrated by social sciences students when engaging in a controversial physics issue and a socio scientific issue?

Like physicists, social science students have sensed the issue is indeed drafting away from physics. Hence they had demonstrated ability to distinguish important questions for a discipline to some point. This ability is related with aspect 3. Also a certain criteria for trustworthy theories was present in the data of social sciences students. This criteria was being compatible with previous theories. It can be regarded as an implication for aspect 1, because it is an identification of an appropriate epistemic ideal. Another reliable process employed by social sciences students was trusting in authorities (scientists). Social sciences student A has thought in order to be certain about her point of view regarding the first issue, she needed to more research. But, later she has admitted that no matter how much she does research she can never be certain. To be certain one has to be a scientist working on the issue. Similar to physicists, social sciences students have believed for an answer to be true, it has to be tested too. Hence demonstrated a behaviour related to aspect 3.

While deciding a point of view regarding the second issue, social sciences students have compared Dr. Steve James' case with a similar one. Hence, comparison was one of

the reliable processes used by them. In terms epistemic ideals, social sciences students have used the criteria not being harmful to society as a criteria for evaluating both sides regarding the second issue.

While engaging with the second issue, social sciences students have transferred their epistemic performance from their prospective field. During the session they have talked about case studies from their prospective field of expertise. Their method suggests they are familiar with controversial issues. Considering their common approach to the second issue, the source of this integrity might be their curriculum. After all they are undergrad social sciences students studying at the same university.

The fourth research question: What are the similarities and differences between cognitive and metacognitive elements of epistemic performances demonstrated by teaching physics students, physics professors and social sciences students while engaging a controversial physics issue and a socio-scientific issue?

Among three groups only the physicists identified whether the universe is fine tuned for life or not as an unimportant question for physics. Furthermore, they have argued the issue is a philosophical one. The first aspect of apt epistemic performance emphasises the ability of identifying valuable products to aim for. The participants from other two groups have not done such an emphasis. Hence in that regard, they haven't demonstrated an apt epistemic performance.

In terms of reliable epistemic process, all three groups have suggested doing calculations, experiments and observation were to be reliable processes for producing or evaluating knowledge claims. Physicists and social sciences student have identified criteria for a theory to be good. There were no such emphasis from teaching physics students. In terms of frequency of demonstrating metacognitive elements of epistemic performance, physicists have demonstrated higher number of aspects compared to other two groups. If we compare the other two group within themselves, it can be seen the social science students have demonstrated metacognitive elements of epistemic perfor-

mance more frequently compared to teaching physics students.

While engaging the second issue, teaching physics students employed their personal experience and ethical values while evaluating the arguments. Hence they thought the outcome for second issue might change from person to person. Social sciences student emphasised the well being of the society. But unlike teaching physics students, social sciences students explained their reasoning. They have supported their point of view by giving examples from their prospective areas. Hence, according to the constraints of the situation, they have adjusted their epistemic ideals and reliable processes while choosing their points of view. Apparently, social sciences students study controversial issues in their courses. Given the controversial nature of the second issue, social sciences students knew where to look while approaching it. This might be the main reason why social sciences students have avoided giving into their emotions. Physicists on the other hand searched for data. Like social sciences students, they have considered the well being of the society. They believed there are enough amount of data for vaccines to be trustworthy. They have not tried to check ethical values. To evaluate both sides of the argument social sciences students used the reliable process of forming analogies with similar cases. They have also used the criteria of being not harmful to society. Physicists on the other hand, used the reliable process of checking the adequacy of data to evaluate the arguments. They have also used the criteria of being not harmful to society. Even though their reliable processes were different, both groups physicists and social sciences students have reached the same conclusion. This reflects the contextual structure (Chinn & Rinehart, 2016) of Apt-AIR framework.

5.2. Implications for Education

As stated in the literature review, it is important for citizens to have epistemic competence and epistemic meta competence so that they can make well-justified decisions in various fields concerning themselves or society. In parallel with this aim, a research study which focuses on cognitive and metacognitive elements of epistemic performance was conducted. Physicists significantly demonstrated how an expert like

approach should look like to a controversial physics issue. They also transferred the adequacy of data from their field of expertise to an issue which concerns the society. These data will be useful for establishing an example to apt epistemic performance and how an expertise can be transferred from one context to another. As stated in the literature review, the only research study which barrows Apt-AIR framework is Greene *et al.*, 's (2021). In that study, a description of how an apt epistemic performance should look like in the field of psychology has been given. Hence, the findings of the current study will make an addition by providing the description of how an apt epistemic performance should look like in the field of physics. The emphasis made by the second group (teaching physics students) on observation and experimentation was common with the physicists. However, none of them has transferred those to the second issue. They have used observations at personal capacity and emotions to assert their views on mandatory Covid vaccine. In that sense, they were different than other two groups. While relying on observations at personal capacity and emotions, they have not demonstrated any metacognitive elements.This means there is a need to increase the awareness of teaching physics students regarding controversial social issues like mandatory coronavirus vaccine and metacognitive elements of physics.

The third group, social sciences students demonstrated a metacognitive understanding regarding the first issue, even though it was not their field of expertise. While talking about the second issue, they have relied on the cases from their prospective field of studies. Hence, they demonstrated a metacognitive understanding. Assuming the main reason for this is the controversial cases which they have covered in their courses, a similar approach can be adapted for the courses of teaching physics students as well.

In the study of Greene *et al.*, (2021), Apt-AIR framework was used to analyse epistemic performance of social scientists, natural sciences scientists and psychologists. All those participants held graduate degrees in their fields. Due to their high level of education, they were considered as experts in their fields by the researchers. Hence, to my knowledge the current study is the first one which adopts Apt-AIR framework as an

analytic framework to investigate cognitive and metacognitive elements of non-experts.

The results of the study suggest there is a deficiency in the quality of the thinking practices in the group of teaching physics students compared to social sciences students. The reason for this might be the familiarity of social sciences students to controversial issues. Hence, teaching physics students' epistemic performance can be improved by including case studies which focus on controversial issues concerning society, in the teacher training curriculum. In those case studies, the preservice should be encouraged to use reliable processes from physics such as looking into data or observation through experimentation. Such an approach would be aligned with National Generation Science Standards' (NGSS) (2013) goals which aim to integrate science and society.

5.3. Direction for Future Research

The results of the study suggest Apt-AIR framework does an adequate job as an analytical framework. In the study, while looking at the sessions of the first issue, the framework helped the researchers to picture physics as a discipline by capturing many cognitive and meta cognitive elements of epistemic performance. Most of those elements were later encountered in the sessions related with the second issue. Hence at some point, there was a transfer of cognitive and metacognitive elements of epistemic performance from the first issue to the second issue. To increase the number of possible scientific practices which can be employed while dealing with a controversial issue concerning the society, a similar study can be done with experts from other scientific disciplines. In the analytical framework used by the current research study, there are five aspects of apt epistemic per-formance. However in the data, aspect 4 was not encountered. Similarly, in the study of Greene *et al.*, (2021) there were no examples for the fourth aspect. Epistemic performance is directed at epistemic aims. And those aims sometimes can be evaluating a knowledge claim or producing one (Chinn et. al., 2021). In the current study and in the previous study which adopted Apt-AIR framework, the tasks encouraged participants to evaluate knowledge claims. Due to that reason, aspect 4 could not been observed. Hence in the future, a research study which uses a

task which encourages participants to produce a knowledge claim to facilitate epistemic performance can be conducted. If there are no implications of aspect 4, there might be a need to revise Apt-AIR framework.

In the study, teaching physics students demonstrated less frequent number of cognitive and metacognitive elements of epistemic performance. This suggests they need to en-hance their thinking practices. Hence, further studies might be conducted to describe the properties of interventions which enhance one's thinking practice.

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APPENDIX A: INDIVIDUAL MEETING PROTOCOL (ENGLISH VERSION)

Introduction:

In the research study, think aloud method is going to be used. The aim of this method is to collect the participant's thought process as data. You will be given the prompt "keep talking" if you stay silent for 15 seconds during the think aloud sessions. You are expected to talk in the same way like you talk with yourself. There are two parts in the study. Each part starts with a think aloud session and continues with interview sessions. If you like you can take a break between two parts.

Part 1: Fine Tuned Universe

According fine tuned universe theory, the universe is fine tuned so that life can flourish in it. In the upcoming video, you will watch an interview conducted with Leonard Susskind. Susskind is a researcher who studies the theory of fine tuned universe at Stanford University. In the video, Susskind talks about briefly what is the theory of fine tuned universe. Then, he introduces few conflicting ideas about fine tuned universe. During the session, in the software which used for playing the video, you can use functions of fast forward, fast backward, pause, play and stop. Also while watching the video, you skip to a time which you desire to continue. Turkish and English transcripts of the video have been printed out. You can find them on the table in front of you. While examining/watching the materials presented to you, I ask you to think aloud the following questions:

What do you think about the knowledge claims presented in the video regarding fine-tuned universe?

Do you think, our universe is fine tuned for life? What are the reasons you hold that

view?

Once you think you have spoken enough about those two questions, you can end the session.

Semi structured interview questions:

- What leads you to hold that point of view?
- On what do you base that point of view?
- How confident are you about your point of view?
- Can you ever know that your point of view is correct? How or why not?
- Can one of the knowledge claims be right? What do you mean by right?
- Can one of the claims be better? What do you mean by better?
- How is it possible that experts in the field disagree about this subject?

Part 2: Mandatory Covid19 Vaccine

The English government has made covid19 vaccine mandatory for healthcare workers who are in direct contact with patients. In the upcoming video, you will watch an argument between two opposite sides; Dr. Steve James who is against this mandate and Dr. Hilary Jones who supports this mandate. During the session, in the software which used for playing the video, you can use functions of fast forward, fast backward, pause, play and stop. Also while watching the video, you skip to a time which you desire to continue. Turkish and English transcripts of the video have been printed out. You can find them on the table in front of you. While examining/watching the materials presented to you, I ask you to think aloud the following questions:

What do you think about the knowledge claims presented in the video regarding mandatory Covid vaccines for healthcare workers who are in direct contact with patients?

Which of the doctors do you agree with Dr. Steve James or Dr. Hilary Jones? What are the reasons you hold that view?

Once you think you have spoken enough about those two questions, you can end the session.

Semi structured interview questions:

- What leads you to hold that point of view?
- On what do you base that point of view?
- How confident are you about your point of view?
- Can you ever know that your point of view is correct? How or why not?
- Can one of the knowledge claims be right? What do you mean by right?
- Can one of the claims be better? What do you mean by better?
- How is it possible that experts in the field disagree about this subject?"
- You have watched two videos. In terms of knowledge claims, can you compare them for me?
- While choosing a point of view for both issues, what were the differences you have encountered due to the different natures of the issues?

APPENDIX B: BIREYSEL GÖRÜŞME PROTOKOLÜ (TÜRKÇE VERSIYONU)

Giriş:

Araştırmada sesli düşünme yöntemi kullanılacaktır. Bu yöntemin amacı kişinin düşünce akışına ilişkin veri toplamaktır. Araştırmanın sesli düşünme kısımları sırasında on beş saniyeden uzun bir süre sessiz kalırsanız araştırmacı tarafından "Konuşmaya devam et" şeklinde uyarılacaksınız. Sesli düşünme boyunca kendinizle konuşuyormuş gibi konuşmanız beklenmektedir. Araştırma iki bölümden oluşur. Her bölüm sesli düşünme faslı ile başlar ve mülakat ile devam eder. İhtiyaç duyduğunuz takdirde iki bölüm arasında ara verebilirsiniz.

Bölüm 1: İnce Ayar Evren

İnce ayar evren teorisine göre evren yaşamın oluşması için özel olarak yaratılmıştır. Az sonra izleyeceğiniz videoda Standford Üniversitesi'nde fizik alanında bu konuyla ilgili çalışmalar yürüten Leonard Susskind ile yapılmış bir röportaj yer almaktadır. Videoda Leonard Susskind, ince ayar evren teorisinin ne olduğunu kısaca anlatır sonrasında konuyla ilgili bilim insanlarının sahip olduğu farklı fikirleri ifade eder. Videonun Türkçe ve İngilizce altyazılı halleri mevcuttur. Çalışma boyunca videonun oynatıldığı programda yer alan ileri sarma, geriye sarma, durdurma, yeniden başlatma veya herhangi bir zamana atlama fonksiyonlarını hiçbir kısıtlama olmadan kullanılabilirsiniz. Ayrıca önünüzdeki kağıtta videonun Türkçe ve İngilizce transkriptleri basılı halleri mevcuttur. Dilerseniz bunlardan faydalanabilirsiniz. Sizden materyalleri incelerken şu iki soruya sesli düşünmenizi rica ediyorum:

- Videoda ince ayar evren ile ilgili sunulan bilgi iddiaları ile ilgili ne düşünüyorsunuz?
- Sizce evrenimiz yaşamın oluşması için ince ayarlı mı? Bu görüşe sahip olmanızın sebepleri neler?

Bu konu hakkında yeterince konuştuğunuzu düşündüğünüzde beni uyarabilirsiniz.

Yarı Yapılandırılmış Mülakat Soruları:

- Sizi bu bakış açısına iten nedir?
- Bu bakış açınızı neye dayandırıyorsunuz?
- Bakış açınızdan ne kadar eminsiniz?
- Bakış açınızın doğru olduğunu bilebilir misiniz? Nasıl bilebilirsiniz veya neden bilemezsiniz?
- Bilgi iddialarından birisi doğru olabilir mi? Doğrudan kastınız ne?
- Bilgi iddialarından biri daha iyi olabilir mi? Daha iyi derken neyi kastediyorsunuz?
- Alanında uzman kişilerin bu konuda fikir ayrılığı yaşaması nasıl mümkün olabilir?

Bölüm 2: Zorunlu Covid19 Aşısı

İngiltere Hükümeti hastalarla doğrudan temas halinde olan sağlık çalışanlarına covid19 aşısı olma zorunluluğu getirmiştir. Az sonra izleyeceğiniz videoda bu uygulamanın yanlış olduğunu düşüne Dr. Steve James ve bu uygulamanın meşru olduğunu düşünen Dr. Hilary Jones ile yapılan haber programı yer almaktadır. Videonun Türkçe ve İngilizce altyazılı halleri mevcuttur. Çalışma boyunca videonun oynatıldığı programda yer alan ileri sarma, geriye sarma, durduma, yeniden başlatma veya herhangi bir zamana atlama fonksiyonlarını hiçbir kısıtlama olmadan kullanılabilirsiniz. Ayrıca önünüzdeki kağıtta videonun Türkçe ve İngilizce transkriptleri basılı halleri mevcuttur. Dilerseniz bunlardan faydalanabilirsiniz. Sizden materyalleri incelerken şu iki soruya sesli düşünmenizi rica ediyorum:

- Videoda hastalarla doğrudan temas halinde olan sağlık çalışanlarına covid19 aşısı zorunluluğu ile ilgili sunulan bilgi iddaaları ile ilgili ne düşünüyorsunuz?
- Hangi konuşmacının görüşüne katılıyorsunuz, Dr. Steve James'in mi yoksa Dr. Hilary Jones'un mu? Bu konu hakkında yeterince konuştuğunuzu düşündüğünüzde

beni uyarabilirsiniz. Yarı Yapılandırılmış Mülakat Soruları:

- Sizi bu bakış açısına iten nedir?
- Bu bakış açınızı neye dayandırıyorsunuz?
- Bakış açınızdan ne kadar eminsiniz?
- Bakış açınızın doğru olduğunu bilebilir misiniz? Nasıl bilebilirsiniz veya neden bilemezsiniz?
- Bilgi iddialarından birisi doğru olabilir mi? Doğrudan kastınız ne?
- Bilgi iddialarından biri daha iyi olabilir mi? Daha iyi derken neyi kastediyorsunuz?
- Alanında uzman kişilerin bu konuda fikir ayrılığı yaşaması nasıl mümkün olabilir?
- İki tane video izlediniz. Videolarda sunulan bilgi iddialarını kıyaslayabilir misiniz?
- Bu iki konuda bir taraf seçerken, sizin için konuların doğasından kaynaklanan nasıl farklılıklar vardı?