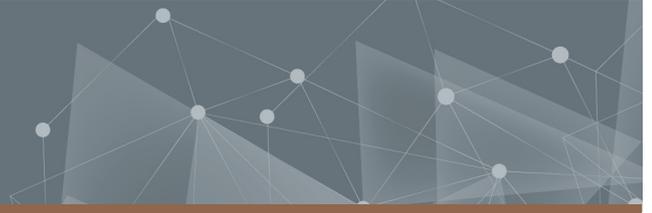




CHALMERS
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How is Physics Hard?

Exploring Upper Secondary School Pupils' Stories About an Ambiguous Subject

Master's thesis in Learning and Leadership

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DEPARTMENT OF COMMUNICATION AND LEARNING IN SCIENCE

CHALMERS UNIVERSITY OF TECHNOLOGY
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Abstract

Physics is commonly presented as a difficult subject. The reasons for why this view is held among upper secondary school physics pupils and university students has previously been investigated. However, what narratives around physics and its difficulties exists among pupils before embarking on post-compulsory studies in physics is a less explored area. The aim for this study was to explore how upper secondary school pupils discuss physics and what narratives about it being a difficult subject they partake in. This was done through the use of semi-structured individual interviews. Ten pupils were interviewed. The results indicate that the pupils interviewed largely construct their understanding of physics through the positioning of physics against other subjects and how other people relate to it. Through this positioning, physics mostly becomes a subject that is largely constructed as being complex, distant, vague and only for those who get it. However, certain attributes assigned to physics do not lead to it being a difficult subject. This mostly occurred in the positioning of physics against mathematics. The results indicate that multiple narratives about physics commonly reported among university students also exist among upper secondary school pupils. This implies that pupils are introduced to common narratives about physics early in their education, which risks affecting who chooses to pursue post-compulsory studies in physics.

Keywords: STEM, Teaching physics, Physics education, Discourses, Narratives, Upper secondary school.

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Beatriz Bento Hansson, Gothenburg, May 2024

Contents

List of Tables	xi
1 Introduction	1
1.1 Aim	1
1.2 Specification of Issue Under Investigation	2
2 Literature Review	3
2.1 The Purpose of Studying Science	3
2.2 Students' Opinions and Perceptions of Physics and Science	4
2.3 Why is Physics Considered Difficult?	5
2.4 How has the Difficulty of Physics Been Explained?	6
2.4.1 What is Meant by Saying That <i>Physics is Hard</i>	7
3 Methodology	9
3.1 Participants	9
3.2 Data Collection	10
3.3 Analysis	11
3.4 Delimitations	12
3.5 Ethical Considerations	12
4 Results	13
4.1 Physics and the Social Sciences	13
4.2 Physics and the Other Natural Sciences	15
4.3 Physics and Mathematics	16
4.4 Physics and People	18
4.5 Summary of the Results	20
5 Discussion and Conclusion	23
5.1 Contribution to Knowledge	23
5.2 Implications for Teaching	24
5.3 Limitations and Future Research	25
5.4 Conclusions	25
Bibliography	27
A The Consent Form	I

B The Interview Guide

V

List of Tables

4.1	The results summarised according to section and how the image of physics is constructed in each section.	21
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1

Introduction

Any university student studying physics has probably encountered the following scenario: In conversation with a new acquaintance, the topic of what subject they are studying comes up and when answering that they are studying physics the response is along the line of “That sounds difficult!”. Physics is widely considered to be difficult, both as a subject in school and as a field of study. This perception risks having an effect on who chooses to pursue physics at post-compulsory level as well as affecting pupils’ self-image and performance in physics courses. All the while, there is a concern about the lack of competence in STEM (science, technology, engineering and mathematics) subjects among the population which risk leading to a shortage in this area and stalling development (Barton & Upadhyay, 2010; UNESCO, 2021). Physics is no exception to this problem and by exploring why pupils find physics to be a difficult subject, teachers can more easily counteract the preexisting conceptions about the subject and allow pupils the possibility to form their own idea of what to think about physics. Understanding the causes of why physics is seen as a difficult subject is a first step in being able to counteract and change these ideas to ultimately enable young people to form more valuable relationships to physics.

While some previous research have explored the difficulty upper secondary school pupils experience studying physics (Angell et al., 2004; Ekici, 2016; Erinosh, 2013) most research is focused on how university students perceive a specific physics course to be difficult (Bray & Williams, 2020; Ornek et al., 2008). Focusing both on aspects to do with the subject as well as how it is being taught. In contrast this study focuses on pupils who have not studied any post compulsory physics, their experiences of the subject, how they talk about the subject and any difficulties with it. This enables a sharpened focus on the stories told about physics before pupils have delved into it beyond the compulsory physics in elementary school. Thus, enabling the mapping of how pupils’ discuss the subject going in to further studies in it.

1.1 Aim

The aim for this thesis is to explore how pupils at the beginning of studying STEM-programmes at upper secondary school talk about physics and it being a difficult subject. The intention is to form an idea of how they talk about the subject before having studied it at upper secondary level. Such knowledge about pupils’ attitude towards a subject can inform how a teacher chooses to talk about physics and structure their teaching of the subject.

1.2 Specification of Issue Under Investigation

In order to gain a full understanding of how physics is discussed and constructed to be a difficult subject, it is important to define how the pupils describe and discuss the subject. Thus, the intention of this study is to answer the following questions.

- How do upper secondary school pupils discuss physics based on their previous experiences and common narratives about the subject?
- Given the narratives about physics that upper secondary school pupils partake in, how do they discuss physics as being difficult?

2

Literature Review

In this chapter an overview of relevant literature on upper secondary school pupils' perceptions of physics and science is presented. Adjacent topics are also addressed to give additional context.

2.1 The Purpose of Studying Science

When approaching the subject of how students regard physics and the STEM subjects, it is worth starting with discussing the role of these subjects, that is, the purpose for them being taught at the compulsory school level. Mandatory education is often considered to be meant to provide pupils with all the skills and knowledge they need to be members of society, the education is meant to provide them with a sort of general knowledge. This idea has been presented in different ways, one being through the idea of *Bildung*, which can be described as education with a focus on individual perspective, valuing “self-determination, freedom, emancipation, autonomy, responsibility, reason and independence” (Klafki, 2000, p. 87, cited in Nicolaisen et al., 2023, p. 217). The concept of *Bildung* does not traditionally emphasise the natural sciences (Nicolaisen et al., 2023), which might be a contributing factor to why they are seen as less useful outside of a career in science. However, the concept can quite easily fit the natural sciences as well, as explained by Nicolaisen et al. (2023) the role of natural science education in *Bildung* would be to contribute to pupils' perception of the meaning of what it is to be a human.

Another related concept, which more closely relates to the natural sciences, is that of *scientific literacy*. Osborne (2007) discusses the need for scientific literacy to be the objective of teaching the natural sciences. He succinctly describes scientific literacy as what everybody should know about science (Osborne, 2007). Today's teaching of the natural sciences, according to him, is mostly focused on teaching facts and such specific knowledge relevant for those who will pursue a future career as a scientist. Scientific literacy is more focused on preparing the future citizen, who needs to understand more contextual information and concepts such as how worldviews are formed, why they are important and how concepts relate to each other (Osborne, 2007).

Very simplified, there is not one unanimous purpose for the teaching of the natural sciences. Its purpose can be seen as to teach the next generation of scientists and its purpose can be seen as to provide citizens with the knowledge and reasoning skills they require to function in society. Whichever purpose a teacher, school or society have will affect how they approach and teach the natural sciences.

2.2 Students' Opinions and Perceptions of Physics and Science

Given the widely spread concern about declining interest in STEM subjects among young people there has been research made looking into the subjects at various levels. For example, DeWitt et al. (2013) explored the perception of science and scientists among pupils aged 10-11, finding two reoccurring patterns. One where children talked about scientists and peers interested in science as clever, and one pattern where they are talked about as possessing certain traits which distinguishes them as different from what is considered most normal, what the authors refer to as a pattern that implies the existence of a science mindset(DeWitt et al., 2013).

An example of the perspective of older pupils can be found in the work of Caspi et al. (2019) who looked into how ninth grade students in Israel reasoned around choosing to pursue STEM degrees at upper secondary school. They found that a majority of students considered the utility of pursuing STEM subjects for future careers. A perspective that we will see echoed among the work centred at physics in particular.

Research narrowed down to students' perception of physics is mainly focused on the experience of university students or upper secondary school students that have completed some post-compulsory physics. These studies often consist of questionnaire studies with predefined questions that are answered using numerical scales or pre-established alternatives. Sometimes the questionnaires are complimented with some other form of data collection, such as focus groups.

Like stated by Caspi et al. (2019) regarding STEM in general, pupils pursuing physics often do so due to them, and society at large, considering it to be a useful subject for future education and careers (Angell et al., 2004; Reid & Skryabina, 2002; Testa et al., 2022). Personal interest in the subject is also a significant factor in choosing to pursue the subject (Angell et al., 2004; Reid & Skryabina, 2002; Testa et al., 2022).

When investigating the attitudes of Norwegian upper secondary school pupils towards physics Angell et al. (2004) found that pupils studying physics considered their subject of study to be difficult, having a fast progression and high workload to a larger extent than pupils studying social science and English. Of course, such views are not homogeneous across an entire group of pupils. Testa et al. (2022) identified a clear distinction in upper secondary pupils' attitudes toward physics between pupils engaged in physics related activities outside of school and those who were not. The former group not only showing a greater interest in the subject but also attributing a greater value to the subject than the latter.

Testa et al. (2022) consider whether a pupil pursues physics or not to be a consequence of whether they feel included in the culture of physics. This can be due to how the subject is taught, for example having an insulatory approach that places emphasis on calculations can lead to pupils feeling excluded (Testa et al., 2022). Reid and Skryabina (2002) also attribute their findings to the curriculum taught to the pupils they investigated. The Scottish pupils partaking in their study did not find physics to be a particularly difficult subject, in contrast to literature they referenced reporting on the situation in England. They state that the curriculum

for the courses, focusing on applications of physics, was a contributing factor to physics not being viewed as a difficult subject. While this last perspective is more of a rarity in pupils' reported attitudes and perceptions of physics, it is of interest to know that the view of physics can vary, and thus be changed.

Attitudes towards the subject of physics is also investigated at university level. Most often through questionnaires such as the commonly used Colorado Learning Attitudes about Science Survey (CLASS) (Adams et al., 2006). The questionnaire is constructed to map to what extent students' attitudes against physics align with that of experts in physics (Adams et al., 2006; Martins & Lindsay, 2022). This is done by having students answer to what extent they agree or disagree to a number of statements on a five point scale. The questionnaire is often administered before and after a course to record how students perceptions evolve across a course. Results suggest that the type of teaching have big effect on students attitudes. (Adams et al., 2006; Martins & Lindsay, 2022) Traditional teaching, with an emphasis on lectures, have been shown to result in a shift among students to a more novice mindset (Martins & Lindsay, 2022).

Another approach to investigating students attitudes to science is exemplified by Wong et al. (2023), who interviewed university students pursuing STEM degrees about how they would characterise the typical and ideal student within their field. They found that STEM students consider an ideal student to be passionate about their subject, hardworking and competent. This was true for the four fields investigated, biology, physics, mathematics and engineering. However, they also found that there was a hierarchy among the disciplines of which subjects were considered harder and easier. Biology being positioned as an easier subject than the others.

Among both upper secondary school pupils and university students physics is seen as an interesting subject that requires more effort than other subjects (Angell et al., 2004; Wong et al., 2023), although it is worth noting that this is the view mostly of students that have chosen to pursue further studies in physics. Similar findings have been documented in a Swedish context, reporting that many elementary school students consider physics to be a boring and difficult subject (Skolin-spektionen, 2010). Given this in addition to Sweden's comparatively average score in physics in the latest TIMSS (Trends in International Mathematics and Science Study) advanced study from 2015 (TIMSS & PIRLS International Study Center, 2016), it is quite likely that findings from other western countries are also largely applicable to a Swedish context. More widely in western society there seem to be a perception of physics as a discipline for those with great passion and ability for it; a subject requiring a certain inclination towards it, that one is smart and that the subject is hard and difficult (Gonsalves, 2010; Johansson, 2020; Schiebinger, 1999).

2.3 Why is Physics Considered Difficult?

That physics is considered to be a difficult subject is a reoccurring conclusion and there has been studies done with the aim to investigate what in particular makes physics a difficult subject (Bray & Williams, 2020; Ekici, 2016; Erinosho, 2013; Ornek et al., 2008).

These investigations appear to often approach the question by administering a

questionnaire to upper secondary school pupils who are studying physics (Angell et al., 2004; Ekici, 2016; Erinosh, 2013) or university students taking a particular physics course (Ornek et al., 2008). In some cases, teachers' views on what students struggle with are also examined (Angell et al., 2004; Ekici, 2016; Ornek et al., 2008).

The results of these papers often identify aspects of varying character that contribute to the perception of physics as a difficult subject. Some aspects are relating to the nature of the subject, as described by Erinosh (2013) and Ornek et al. (2008), while other aspects identified have more to do with the teaching, structure of a particular course or students' study technique. Among both upper secondary school and university students two aspects were mainly identified as difficult in relation to the nature of the subject. Firstly the need to apply mathematics (Angell et al., 2004; Erinosh, 2013; Ornek et al., 2008). In the case of Angell et al. (2004) they supplemented their questionnaire with focus groups and could therefore specify that pupils principally found the description of physical phenomena using mathematics as difficult. Erinosh (2013) also reported that upper secondary school teachers considered the need for mathematical ability to be a contributing factor to pupils struggling with physics. The second aspect commonly reoccurring was that pupils and students considered the amount of material covered to be a cause for difficulty. In the case of university students another aspect was identified. Ornek et al. (2008) reported that the most frequent cause given for physics being difficult was the cumulative nature of the subject, that the grasping of a new concept require understanding of the previous.

In the studies where the teachers' perspective are investigated there are some discrepancies found between students' perceptions of their abilities and difficulties with physics and that of professors and teachers (Angell et al., 2004; Ekici, 2016; Ornek et al., 2008). This is most often the case when it comes to the use of mathematics in physics as shown by for example Angell et al. (2004) and Ornek et al. (2008), where teachers either places a greater importance on mathematics than the pupils or to a further extent consider lack of mathematical ability to be the reason for students to struggle.

2.4 How has the Difficulty of Physics Been Explained?

A part of teachers' understanding of where students are at in their education and learning is for them to understand how pupils view physics and if they have any difficulties with the subject. However, as has been established in previous work, the idea that physics is a difficult subject is not confined only to those studying physics. Therefore, it is also of interest to understand how students view physics before they embark on studies in the subject.

Having an idea of students' perceptions of a subject is of interest to understand attitudes and tendencies towards further studies in the subject. However, in order to change the tide of negative discourses of a subject it is of interest to gain an understanding of existing discourses and patterns of talking about the subject. If there are great misconceptions or negative attitudes toward a subject, knowledge

about these misconceptions and attitudes are necessary to counteract them. The earlier on in education this can be mapped and combated, the larger the chance that more students can gain their own perception of a subject and that people, who otherwise would not, continue studying the subject.

2.4.1 What is Meant by Saying That *Physics is Hard*

The questions posed in most of the articles discussed is “Why is physics hard?”, which the authors proceed to answer without much of a specification of what they mean by the question. While the framing of the question and the type of answer one seeks can vary, it is also important to establish a consensus on what is meant by *physics* and *hard*.

For those who work with physics education or have studied the subject there might not seem to be a point in asking what physics is. However, for upper secondary school pupils the answer might not be as obvious. How pupils answer the question and how well the answer lines up with the curriculum they are studying might also affect their experience of studying physics, their perception of the subject and whether they choose to pursue the subject at university or not.

Regarding physics being hard, what is most often meant is that physics is a difficult subject. However, the word hard in English has multiple meanings, all of which, to some extent, could be applied when describing physics. Schiebinger (1999) describes three different meanings of hard: epistemologically, ontologically and didactically. Epistemologically hard, due to physics being a structured subject, relying on logic, seen as abstract and quantitative. Ontologically hard, due to physics studying concrete, solid objects in contrast to softer sciences studying softer things such as organic matter, including humans and their behaviours. Didactically hard, as in requiring the investment of much work and time as well as a good ability to think analytically and abstractly. (Schiebinger, 1999)

Talking about something as hard implies the existence of something soft in contrast, so when stating that physics is difficult it implies that there are subjects that in contrast are easy. A common concept when comparing physics to other STEM subjects is the idea of a hierarchy among the subjects, with mathematics and physics having a perceived high status while “softer” subjects such as biology is placed further down (Schiebinger, 1999; Wong et al., 2023). This hierarchy can also be seen as a hierarchy in terms of how fundamental the subject is. A common view being that physics is applied mathematics, chemistry is applied physics, biology is applied chemistry and so on (Gonsalves, 2010). The hierarchy can also be seen to correspond to the perceived difficulty of the subject, to some extent as an implication of how fundamental the subject is. Meaning that physics, considered to be a subject describing the most fundamental parts of the world thus must be a difficult subject (Gonsalves, 2010).

The idea that physics is a difficult subject brings implications as to what is required of students pursuing the subject, either one has to be talented or put in a lot of effort, possibly a combination of both. Among students pursuing physics at university there seems to be a common idea that to succeed in physics requires a measure of inherent talent (Johansson, 2020). Ideas along the same lines are

expressed by the elementary school pupils interviewed by DeWitt et al. (2013). Thus, suggesting that such ideas and perceptions of physics and science are established quite early on. Therefore, it is not unlikely that students might conform to these patterns of talking about physics as a subject and it being difficult early on in their education, which might influence whether they pursue the subject.

The favouring of ideas such as that natural talent is required to succeed in physics rather than “only” hard work can have negative implications in a learning environment. If the general idea is that an inherent predisposition for the subject is required to succeed at it there will be little incentive for a student to apply themselves in physics. If a student does not believe that they can improve if they put in the work, they will never get to know how far they could reach. This reflects a fixed mindset in Dweck’s theory of mindsets in learning (Dweck, 2006). If one has the idea that one is either good or bad at something and that no amount of effort can change that, then one has a fixed mindset. The image of physics, as described in this chapter, is aligned with the idea of a fixed mindset through the idea that certain people are more inclined towards the subject.

Similar results have been reported from students taking physics. For example, Archer et al. (2020), when interviewing British A level students about their upcoming university studies, found that the young women interviewed, even when having performed excellently in physics, did not consider themselves good enough to pursue the subject at university level. These being students that also talked about physics as a subject not only for clever people, but specifically for clever people that did not have to put in any effort to understand the subject. An idea the authors termed as the “effortlessly clever physicist”, and which was not as prevalent among the male students interviewed (Archer et al., 2020).

This along with many of the other studies not only points toward a common idea and understanding of what physics is as a subject, difficult and for smart people, but also indicates what the consequences of these ideas are. The upholding of them risks excluding students that do not see themselves in the narrow mould. In order to break the mould a deeper understanding of how students talk about and understand physics, and it being difficult, is needed.

3

Methodology

As previously mentioned, the aim of this thesis was to study the discourses of physics among those pupils who have not chosen to end their physics studies but have yet to begin studying physics at upper secondary school. This was partly in order for the study to be feasible to complete within the given time-frame, but also because any increase in university students studying physics will most likely be an increase from the pool of pupils already showing an interest for STEM subjects. As mentioned in the literature review it is likely that pupils already have ideas about physics as a subject and about who is well-suited for studies in the subject. The chosen methods was individual, semi-structured interviews with pupils, followed by a thematic analysis of what appears as shared

3.1 Participants

For the sake of efficiency, and to be able to allocate more time to conducting interviews than the recruitment of participants, interviews were conducted with pupils from two different schools in the Gothenburg region. The student body of both schools consisted mostly of pupils with a middle-class background. The pupils interviewed were all in their first year of upper secondary school. Neither of them have studied physics at upper secondary level yet. Thus, the probability that the pupils have had their view of physics influenced by one common physics teacher is quite small, given that students at upper secondary school tend to have studied at different elementary schools. As an extra precaution, the pupils were asked which elementary school they had attended, to ensure that not too many pupils had been taught by the same science teacher. Overall, the ten interviewed students had attended eight elementary schools.

Eight participants were pupils studying the Natural Science Programme at one school and two were studying the Technical Programme at the other school. The thesis and procedure for the interviews were verbally presented for the pupils, the information is equivalent to that presented in the consent form in appendix A. After the information was given pupils interested in participating registered their interest. They were then contacted and an interview was scheduled. The selection of participant was mostly random with some influence from the legibility of the interested pupils' contact information. Some consideration was taken to the gender distribution of the group of participants, resulting in six boys and four girls being interviewed.

3.2 Data Collection

The data collection consisted of ten individual semi-structured interviews conducted with upper secondary school pupils at two schools.

Interviews were chosen to allow for a more nuanced and in-depth understanding than what could have been attained through for example questionnaires. Since how a person views a subject and how they express their view of a subject can vary considerably, semi-structured interviews were preferred over structured interviews as they allow for the interviewer to adapt to the subject. The use of semi-structured interviews allowed for a fuller picture of the pupils' perspective on physics by providing flexibility to adapt the interview to pupils' answers and experiences. Interviews allows for more exploration of what pupils mean when using certain words and expressing ideas and opinions.

This method was chosen, above for example focus groups interviews, to avoid any influence pupils might feel from peers. A focus group interview might not have produced everyone's perspective properly, participants could have been uncomfortable with expressing their views in front of others or could have been influenced by what was expressed by others. Thus possibly limiting the representation of different discourses of physics.

Although, it is also important to note that what is said in the interviews is not an objective truth. Rather the material is approached as a representation of how pupils discuss physics in various contexts, such as at school or, if applicable, with friends and family.

Each interview followed an interview guide consisting of questions around pupils experience of physics from elementary school, their expectation of physics in upper secondary school as well as any experience they had of the subject from personal interest or family members work or education. Most of the questions related to experiences in school focused on peers reaction and opinions of physics in the interest of making it easier for the participants to share their experiences and thoughts. For each question there was a number of follow-up questions which were asked if there was more to elaborate on from the initial answer. At times other follow-up questions were more suited for the situation and was then asked, for example if a particular word or statement needed clarification or elaboration.

Before the interviews were held two trial-interviews were conducted in order to evaluate the interview guide. The interviewees for the trial interviews were university-aged, one of which had not taken any post compulsory physics courses. Minor tweaks were made to the interview guide following the trial interviews.

The interview guide can be found in its entirety in appendix B, note that the interview guide is written in Swedish.

The interviews were held at the pupils' school, either before their first lesson or after their last lesson of the day. Each interview lasted approximately 30 minutes and the interviews were held over the span of a couple of weeks. The interviews were held in Swedish, being the native language of the participants. The recordings of the interviews were transcribed, in the process removing all identifying information of the participant. Each participant was also assigned a pseudonym which is used when quoting their interview. The quotations chosen for the thesis were translated

by the author from the transcriptions.

3.3 Analysis

Thematic analysis was used as a framework for the analysis, following the six phases as outlined by Braun and Clarke (2022). The phases being familiarisation with the material, coding, generating initial themes, developing and reviewing themes, defining and naming themes and finally writing it all down (Braun & Clarke, 2022). The nature of these phases is cyclic, a move from one phase to the next does not hinder the return to the previous phase to rework and elaborate. The initial phases were also performed concurrently as the interviews were conducted. The approach of thematic analysis was chosen as its flexibility meant that there was no concern of whether the data would fit any particular framework. Thematic analysis was deemed a good foundational qualitative analysis that allowed for further exploration. The material could be approached and explored from various perspectives, both looking at it with a more deductive approach in relation to previous work but not entirely losing the inductive side. This allowed for the focus and development of the aspects that were strongest.

The recordings of the interviews were transcribed, focusing on capturing the meaning but not every linguistic detail of the conversation. The transcription process allowed for an initial familiarisation with the material, the first phase of thematic analysis. This process was started as soon as the first interview had been conducted and occurred in parallel to the following interviews. This allowed for some time to process the material as well as informing areas of interest for the following interviews.

The second phase of coding was initiated once a few transcripts had been completed. Using the software Nvivo, codes were created based on two of the initial transcriptions, then the rest of the transcriptions were coded using those codes, occasionally adding new codes from the other transcriptions. Some codes used include “Physics is complex”, “Lack of context” and “Doubt about passing physics”. Once an initial coding had been conducted, the material was studied again, the codes re-evaluated and modified accordingly so as to represent the patterns of the material.

Once the coding was completed it was time to move on to the constructions of the themes. During this process, preliminary themes were formed, which were then reworked after discussion with supervisors and further consultation of the material. Once the themes had been established they were more precisely defined to allow for the documentation of the results.

In describing and discussing the results the word “narrative” is commonly used. The use of the word narrative refers to discussions around similar themes and ideas. A narrative being a way to construct and convey ideas about something. The focus in this study is thus on the narratives that pupils partake in about physics and it being difficult for example as expressed in how they discuss physics or how they classmates relate to physics.

3.4 Delimitations

There may be multiple reasons as to why a pupil chooses to pursue a certain education and since the area of interest for this study is physics, the investigation will be limited to the perception of pupils who have chosen to study either the Natural Science programme or the Technical Programme at upper secondary school, thus having chosen to pursue STEM subjects. How pupils pursuing non-STEM related programmes talk about physics being a difficult subject will not be investigated.

3.5 Ethical Considerations

Since the data collection consists of interviews with upper secondary school pupils there was a possibility that some of the collected data was sensitive. Great importance was placed on ensuring that informed consent was given by the participants and that Chalmers guidelines for data collection were followed along with the GDPR law. The consent form used (in Swedish) can be found in Appendix A. The aim was also to follow the guidelines from the Swedish Research Council for good research practices (*God forskningssed*, 2017). Great care was taken when handling the data and ensuring the participants' anonymity by not transcribing any identifying details. Any identifying information was kept separate from the transcriptions.

4

Results

When talking about physics, the interviewees almost exclusively did so in relation to other things, often to other subjects but also in relation to people and how they relate to the subject. Given this, the data was interpreted as consisting of four prevalent themes, three where physics is positioned against one or more subjects and one where physics is positioned in relation to peers and the interviewees themselves.

The first theme concerns the comparison of physics to the social sciences - history, geography, religion and civics. In this comparison, physics was presented as the more difficult subject, requiring more effort and understanding in contrast to the social sciences, which were positioned as subjects where less understanding was required and where it was possible to simply write a lot and reason to the correct answer. The focus of the second theme is on how physics was positioned against the other natural science subjects - biology and chemistry. Here physics was positioned as a more complex subject, requiring more background knowledge than the other subjects, particularly biology. The third theme is on the relation between physics and mathematics. Here the pupils discussed mathematics as a subject that peers considered difficult, which led to them considering physics difficult, due to its use of mathematics. However, they did not position mathematics or its incorporation into physics as a difficulty for themselves. The last theme elaborates on how students perceive people who are good at and engage with physics and how they align themselves, or not, to this type of person. When discussing physics, the pupils often did so from the perspective of the school subject, especially when talking about physics in contrast and comparison to other school subjects. Occasionally students talked about physics in general, mostly when discussing the wider purpose and properties of the subject.

4.1 Physics and the Social Sciences

The positioning of physics in relation to the social sciences was done in two ways. At the most general level, physics as part of the natural science subjects – physics, chemistry, and biology – were contrasted to non-science subjects, almost exclusively civics and the other social study subjects – history, geography and religion, and at a more specific level physics by itself was contrasted to one or more of the social science subjects. The natural science subjects are being positioned as requiring pupils to know the material “properly” in contrast to social sciences where the view was that it was possible to argue and reason to reach a satisfactory answer.

Because people think that the science subjects and maths are the most

difficult ones in ninth grade [last year of compulsory school]. Those are the ones that... It is not about information, you have to know. If you get what I mean? ... Yes, like in the social sciences you can just write and reason to infinity and you just get the right answer, somehow. Everyone says that you can just reason your way to the right answer. (Oscar)

Another way this positioning was presented was through the common idea of the natural science subjects (and mathematics) as subjects constituting of “right and wrong”, whereas other subjects are more about arguing and reasoning which can be seen as more of a skill to possess rather than knowledge learned.

When positioning physics in particular to the social sciences the discussions were focused on the perceived connection to pupils’ everyday life. Physics is not seen as something that affects them in their everyday life or, more precisely, not something they think about. “Then it is more that I don’t care directly how gravitation works. It will work anyway. I don’t really need to know about it to live.” (Ella) This was further apparent in the way that pupils did not see a purpose for the physics they were taught in elementary school in their own lives, feeling that physics was something contained within the walls of school. This went as far as expressing that physics class only served a purpose for those who would choose to pursue further studies in the subject. “Elementary school physics is there for building up a base in case you want to continue studying physics.” (William) This ties into questions of the purpose of physics (or any subject) in elementary school and how that purpose is communicated to and instilled into pupils. The quote above expresses a viewpoint that is opposed to the ideas of *Bildung* (Nicolaisen et al., 2023) and scientific literacy (Osborne, 2007). Instead of the teaching of physics serving a broader purpose for the sake of preparing a pupil to become a well-rounded citizen or for their own personal development, it is seen as being only for those who intend to specialise within the field of physics. With this viewpoint it is not a stretch to imagine that students who do not want to pursue further studies in physics will see no purpose in studying it.

However, not all pupils interviewed discussed physics and the teaching of it in these terms. There were some pupils that had an explanation for the purpose of learning physics.

I think I would say [regarding the purpose of physics] that it is about understanding why things happen and why things are the way they are. And understand in a different way. Gravitational forces, car crashes and everything. It is really important to know physics and be aware of it. (Maja)

All of this paints the picture of physics compared to non-science subjects as being a subject that requires more precise learning and deeper understanding, yet whose application in pupils’ everyday life is not as obvious (for most pupils). This gives the image of physics as a strict and distant subject. Both of these aspects contributes to the image of physics as a difficult subject, one that is further solidified when comparing physics to its fellow natural science subjects.

4.2 Physics and the Other Natural Sciences

When narrowing the comparisons down to the natural sciences the perspective was shifted. Less focus was placed on different types of knowledge and more on the perceived depth of the subjects. Most succinctly expressed “Or rather I know that biology is built upon chemistry which is built upon physics which is built upon maths.” (Julia) This relates the natural sciences and mathematics to each other in a way where mathematics and physics is positioned as the foundation for chemistry which in turn is the foundation for biology. This places biology as a science derived from the other natural sciences and mathematics and physics as more fundamental sciences, implying a hierarchical structure with mathematics being the most fundamental layer upon which the layers of physics and the other natural sciences are built.

While an explicit ordering of the natural sciences was uncommon, biology was singled out from chemistry and physics as being the easier science subject. It was positioned as less demanding and complex than the other natural science subjects. For example, one student when discussing an idea he had encountered about how certain things can not be explained linked this idea to physics and chemistry but did not consider it to apply to biology. “[Referring to a mathematician] and how he said that one cannot explain everything, which is relevant for many physicists and biologist... no biologists don’t go in to it as much, but chemists.” (Lucas) This is in line with views expressed by university pupils talking about the STEM subjects and positioning biology as an easier subject (Wong et al., 2023). It is interesting that these patterns of discussion are already appearing among pupils at the beginning of upper secondary school.

Another way that physics was positioned in relation to mainly biology was through the perspective that physics in elementary school never provided the full picture, due to it being too complex for the educational level. Physics (and chemistry) was seen as both a very layered and complex subject. “In chemistry and physics there are all this background stuff that you have to understand to understand the bigger picture. You cannot do that until you study at university or are doing your PhD on it.” (Ella) This positions physics as a subject requiring a depth of knowledge for complete understanding in a way not required in for example biology. The perceived lesser complexity of biology ties into the perception of biology as the easier science, one that is less complex, not requiring the same depth of knowledge. Similar views about physics being a subject where context is not always given has been reported from pupils at the end of upper secondary school, stating that they in physics need to learn without understanding why something is the way it is (Holmegaard et al., 2014).

In relation to the other natural sciences, specifically biology, physics is considered more difficult and more complex. The pupils’ ideas of the complexity of physics, concerned a complexity of depth, as outlined above, requiring a deeper understanding, but also in breadth, in requiring a broad understanding of how different phenomena are interconnected.

It is often that that is difficult, one can understand one thing but then it can be difficult to connect things. Like connections, very much how

things affect each other and reasoning in multiple steps are probably what was a bit more difficult, because then you have to think a step further. (Julia)

The relationship between the natural science subjects can also be interpreted to be tied to the understanding of what the subjects entail and their connection to everyday life. Biology as being about living things that often can either be seen or have a close connection to everyday life, quite literally so. Whereas chemistry is about matter at a level rarely visible to the naked eye, giving it a similar distance from everyday life as physics. However, physics could be seen to be a further step away since it deals both with very large things such as planets and very small things such as atoms and how phenomena at the atomic level relates to phenomena noticeable to humans. “I think there is a lot of stuff. It is like, like Swedish, that is text. Physics can be throwing a ball, but it can also be the speed of light. And spaceships and how antennas are placed. ... It is a bit more broad than Swedish can be.” (Alexander) This pattern is further supported by most pupils interviewed expressing some uncertainty about what was physics and what was technology or chemistry. “Why does one study technology and physics if it is the same thing?” (Hugo) If asked what the three science subjects were about, pupils would likely give more concise and narrow answers to what biology and chemistry is about than they gave for what physics is about (the most common answer being to explain the world). “Chemistry is more about the elements and substances. The elements and how they react with each others. I think that is easier to understand than physics. Physics is forces and like... Yeah...” (Alexander) This uncertainty could likely be attributed to the nature of natural science at compulsory school, often being taught by the same teacher, one subject at a time in rotation. Another likely cause for uncertainty is of course also the interview situation and a reluctance of saying something wrong.

When positioned against the other natural sciences physics is constructed as a fundamental and cumulative subject which contributes to it being perceived as difficult. Another aspect of physics is formed by pupils discussions of physics and the natural sciences, that of physics being a vague subject, one they cannot quite grasp. There is, however, one subject that has a more varied relation to physics, which will be further elaborated on now.

4.3 Physics and Mathematics

The case of physics and mathematics is quite different to the relative continuum of the other subjects. At the same time mathematics is the subject most frequently brought up in relation to physics, as the subject most similar to physics. This is either done due to calculations being introduced into the last year of elementary school physics or as an expectation of what upper secondary school physics will be like. “Like the maths-parts feels like it increases a lot more in upper secondary school, from what I’ve heard at least..” (Hugo)

Mathematics is discussed as a reason for physics being considered difficult by elementary school classmates. “But I also think that the general perception of physics was "Oh no, are we having an extra maths lesson now", a bit like that.”

(William) While most seemed to simply accept that mathematics was a subject that some found more difficult, one explanation was given as to why mathematics within physics was considered difficult by peers. The actual difficulty was not in performing the calculations, but rather understanding what values to insert into a given formula and what steps to do in order to get to the desired result.

I don't have any problems with maths. But I know that others have trouble with going from like having a formula, what am I supposed to insert where and what am I meant to get out from it then and like that thought process is in multiple steps ... so it is like multiple steps, you get something and then you get something else and then you put it into a formula. Then you get something out of it. So when one starts going into more of that it is always a bit difficult.. (William)

This positions mathematics, or rather the performing of calculations, in physics as the medium through which problem solving becomes a more complicated process. This process is then what is considered difficult.

The perception of physics in upper secondary school (passed on from peers mainly) was that it involved a lot of mathematics and that it was difficult. "... it is supposed to be really difficult, that it is only maths and that it is like really difficult...." (Emma) However, for the interviewees, mathematics was rarely seen as a difficulty, occasionally it could be used as a way for pupils to make physics seem more approachable and enjoyable for themselves.

I've heard that there is going to be more maths in physics in the future and a bit more calculations with different types of forces and formulas and stuff like that. It seems a lot more fun because I think maths is more fun than just doing these study-parts. Maths feels like a lot more fun. (Hugo)

A way of reasoning that should not be surprising since all the pupils interviewed had chosen one of the two most math-intensive programmes at upper secondary level. Thus, it is not surprising that the pupils diverge from the common view that mathematics is difficult. This reasoning can be useful in terms of making physics more concrete and less nebulous. However, with that reasoning physics would only be considered easy as long as the pupil is not struggling with the mathematics. Approaching physics with the impression that it is more mathematics does not necessarily include why the mathematics is there and what it is used for.

One approach to relating mathematics and physics that gets closer to the use of mathematics in physics is exemplified by a pupil who drew the parallel to how mathematics is used in chemistry.

But then my mum has also said to me, as I said before, that it is about the same types of calculations in chemistry and once I got the grasp of those and learned them they have been quite easy for me. So then it feels like it will work out with physics as well, so it does not feel really difficult.... (Emma)

Here, the pupil positions the use of mathematics in physics as equivalent to the familiar experiences of the use of mathematics in chemistry. This results in the conclusion that the use of mathematics in physics will not be a great difficulty for her since she does not find the application of mathematics in chemistry to be a great challenge

When inspecting how the pupils talk about the mathematics in physics more closely, they do however not seem to have a very clear idea of the relation between mathematics and physics, if they elaborated on the topic at all. In the previous section, on physics and the other natural sciences, one example of the view of the relation between the two subjects was presented with mathematics as the foundation of physics. Another view presented in the interviews was that mathematics is a tool used to explain physics “...be able to explain the universe and life with simplified models and then we most often use mathematics which is... I think it even said that it was the best tool that physics has to be able to explain.” (Lucas). These two positionings of mathematics in relation to physics, one positioning mathematics as the foundation and the other positioning it as a tool, creates the image that the role of mathematics in physics is not clearly defined among the pupils. From a more concrete perspective, there was rarely any elaboration on how mathematics is incorporated into physics except for instances of a connection that calculations on forces are performed. “... like doing calculations with forces.” (Emma)

The positioning of physics in relation to mathematics is less cohesive than physics and other subjects. Mathematics is discussed as a subject that others find difficult while the interviewees rarely considers it to be a great concern. With mathematics being positioned as considered difficult by elementary school peers the incorporation of it into physics is often given as a reason for others to find physics difficult. For the interviewees, who have chosen to pursue further studies in mathematics and the natural sciences, the incorporation of mathematics into physics is likely not the main concern for their future studies. That there is a connection between physics and mathematics is something that the pupils agree on and which makes physics more concrete by relating it to a familiar subject. The nature of the connection between physics and mathematics is less clear, however. Since they have barely any first-hand experience of using mathematics in physics their perceptions are largely coloured by what they have heard regarding the physics they are about to embark upon. These rumours about upper secondary school physics will be further elaborated on below.

4.4 Physics and People

In describing people who are good at or works with physics there were repeated ideas of the sort of attributes they had. A common idea was that of a person who has a good understanding, can see connections and is smart. “I would describe them as being very knowledgeable, it feels like there is a lot- because physics is like how... It explains how everything works and like, yeah how everything is.” (Oscar) These ideas also extended to talking about themselves, either when aligning themselves as a person possessing characteristics that made them suited for physics or positioning themselves as not possessing talent required for the subject. When examining how physics is positioned in relation to people, a re-occurring theme was also that of

physics being positioned as a difficult subject by others. This was mostly done by older peers who had studied some physics at upper secondary school.

A person interested in and good at physics was often characterised as someone who understood properly, was knowledgeable and smart. The idea of the need for understanding is in line with the ideas presented previously that physics is a subject that requires one to understand the subject “for real”.

This deeper understanding that is expressed as an attribute for success in physics can either be acquired through (hard) work or be an inherent trait that a person possesses. However, there is a clear bias toward the latter point of view. “One is smart because one has managed to understand these situations. One has managed to connect these things that are difficult to connect. That maybe not anyone could... Or maybe one could do it if one works a lot.” (Ella) This positions physics mostly as a subject one either has a natural disposition for or not. Not only is it a subject for smart people, but smart is not something one can become, it is something one either is or is not. The idea that scientists are clever has been documented to exist among elementary school pupils (DeWitt et al., 2013). This implies that the pupils have a rather fixed mindset (Dweck, 2006) where success in physics is regarded as something due to inherent attributes rather than the result of effort.

The view that a knack for physics is something one either has or has not extends to how pupils talk about their own achievements.

“... my natural ability to learn physics, it is not that good... But in general, if I compare myself with others, then I have it a bit difficult with physics.” (William) Despite applying themselves to great results (in terms of grades) they still do not consider themselves to be good at physics, echoing the reasoning observed by Archer et al. (2020) among pupils reasoning about their choice of university degree to pursue and the idea of the “effortlessly clever physicist” (Archer et al., 2020).

There are also examples from the other end, of pupils regarding themselves as the sort of person that *has* the right mindset or way of thinking for physics. “... I guess I have gotten my logical way of thinking in maths from him [referring to her father] so I guess that has helped me out in the natural sciences as well.” (Julia) Pupils with this perception tend to not necessarily see physics being difficult as entirely negative. Either having the approach that it will be difficult initially when everything is new or that the difficulty means that it will be challenging in a positive way. This positioning of pupils as physics people or as possessing the traits required for succeeding in the subject can also be done by others. For example one pupil discussed physics in upper secondary school and how her older sister had struggled with it. However, she did not think she would find it as difficult, since her mother had told her that she had another way of thinking than her sister, and that this would make physics easier for her.

When talking about the physics course that the pupils will study next term, their perception is heavily influenced by what they have heard about physics at upper secondary school.

Although like... As soon as one hear physics one thinks of it... that it is difficult. I have plenty of friends that are studying the Technical Programme and taking the Physics 1 course [the first physics course at upper secondary school] now and they say that it is like the most difficult

thing they have ever done, so one gets a bit frightened. (Oscar)

Apart from the obvious downside of physics having the reputation of being a difficult subject at upper secondary school, the rumours (or the parts that sticks in pupils' memory) are often lacking nuance about what is causing the difficulties that would help pupils determine whether these difficulties might apply to them. "...and then I have a friend who is studying the Natural Science programme and who has also begun with it [the first physics course at upper secondary school] and he doesn't understand a thing. And then the question is, will I understand anything?" (Lucas) This general perception of physics as a difficult subject contributes to an uncertainty among pupils towards the subject. This uncertainty can also be seen as an existing undercurrent in their view of the subject as complex and layered.

4.5 Summary of the Results

The through line in the results is that pupils will often discuss physics in relation to something else. Most often this is done in relation to another subject, but it is also discussed in relation to how people relate to the subject. The chapter is summarised in Table 4.1, where each section in the chapter is in the column to the left. The middle column contains the different ways physics is positioned in the section. To the very right, the consequence of the positioning is summarised in how it constructs the idea of what physics is. This is done using adjectives that describes the properties of physics given how it was positioned and discussed.

Most of the adjectives associated to physics explains in what ways physics is discussed as difficult. For example, strict, distant, complicated and vague. However, there is also room for other properties that do not as directly relate to physics being difficult, such as fun and fundamental.

Positioned in relation to	Positioned as...	Results in physics becoming:
Physics and social sciences	... requiring “proper” understanding. ... not relevant to everyday life.	Strict Distant Irrelevant
Physics and natural sciences	... the foundation to the other sciences. ... cumulative ... as less clearly defined.	Fundamental Layered Vague
Physics and mathematics	... difficult (for others) due to mathematics. ... more fun (for some) due to mathematics. ... in some (unknown) way tied to mathematics.	Complicated Fun More concrete
Physics and people	... for inherently smart people. ... something I do not have a natural understanding for. ... something I have a disposition for. ... something people say is difficult.	Exclusionary

Table 4.1: The results summarised according to section and how the image of physics is constructed in each section.

5

Discussion and Conclusion

5.1 Contribution to Knowledge

The research questions formulated for this thesis were as follows,

- How do upper secondary school pupils discuss physics based on their previous experiences and common narratives about the subject?
- Given the narratives about physics that upper secondary school pupils partake in, how do they discuss physics as being difficult?

The results show that the interviewed pupils largely discuss physics by positioning the subject against other subjects and how other people relate to the subject. Through this positioning physics is assigned relational attributes which depend on what physics is compared to. Many of these relational attributes shows how physics is constructed as difficult. However, when positioned against mathematics, physics is less often constructed as difficult.

The results points to an uncertainty among the pupils interviewed regarding what physics is as seen by how they generally make sense of the subject by positioning it against other subjects and peoples' reaction to it. This positioning results in physics becoming a vague, fundamental subject that due to its complexity requires a deeper level of understanding. However, it can also be a fun subject that due to the incorporation of mathematics becomes more concrete. These properties contribute to the discourse of physics being an exclusionary subject, best suited for smart people who understand the subject without much effort.

The exploration of how pupils talk about physics before beginning a post-compulsory course in the subject has not been extensively done previously. The running undercurrent of uncertainty among the pupils' narratives about physics illustrates an additional reason for the subject being difficult. If pupils do not have confidence in what physics is, it is near impossible to feel that it is an easy or understandable subject.

Many of the narratives brought up about physics echoed those identified in previous research. Some of these include that physics is difficult due to the use of mathematics (Angell et al., 2004; Erinosh, 2013; Ornek et al., 2008) and the cumulative nature of the subject (Ornek et al., 2008). The narrative that physics require a deeper understanding and that it is for smart people that properly understand the subject is also familiar from previous work (Archer et al., 2020). The results diverge from previous work in that the pupils are earlier in their education than in other studies. All the previous work referenced has at the very least investigated

the perspective of pupils who have already studied some physics at upper secondary school or post-compulsory level. That the pupils interviewed for this thesis are already discussing physics and its difficulty in a similar way imply that the pupils are introduced to these narratives about physics before they choose what subject areas to specialise in.

5.2 Implications for Teaching

Teachers can use the results as a guideline for where to place emphasis and be extra clear and thorough when teaching. The results indicate that pupils are introduced to common narratives of physics even before they make the decision as to whether pursue further studies in the subject. Thus, the most effective changes that can be made to counteract these narratives are to be made in how the subject is approached in elementary school.

One way to work against the narrative held by many of the pupils interviewed is to ensure that pupils understand why they should learn physics. That pupils are unable to see the purpose of what they are being taught could be seen as a failure of the teaching they got at elementary school since there were some pupils that identified physics in everyday situations and saw a purpose for the subject in elementary school beyond that of preparing for further specialisation. Aligning teaching with concepts such as *Bildung* (Nicolaisen et al., 2023) or Scientific Literacy (Osborne, 2007) could be one way to form a contrasting, more grounded, narrative of physics and its purpose.

As well as working on how pupils perceive the purpose of physics, another way of working against the narrative of physics as a vague and distant subject is to take some time to discuss what physics is. As expressed in the results, pupils felt insecure about their knowledge of physics and what is and is not physics. By making sure that pupils understand what is part of the subject and what is not, the pupils will also gain confidence in their understanding and knowledge. This is especially important if the same teacher is teaching all the natural science subjects.

Some aspects might be more difficult for a teacher to address, such as physics being complicated and cumulative. In that case it is more a question of how to best approach this aspect of the subject. For example, by paying attention to how the subject is talked about in the classroom. Here it might be helpful to use growth mindset as a guidance (Dweck, 2006). If there is one aspect or concept pupils tend to struggle with it is important to emphasise that it is possible to understand the concept if one puts in the work.

Most of this is also relevant for upper secondary school teachers, however, they might be in the situation of trying to establish new narratives about physics among pupils where narratives like the one presented in the results are already well established. While this might make the likelihood of a pupil subscribing to a new narrative quite low as a teacher one can still strive to present a new perspective in ones teaching. This is naturally harder said than done, especially if one considers that the teacher is likely familiar with the existing narratives of physics.

5.3 Limitations and Future Research

The methodology chosen was well suited for the chosen research questions. However, there is of course always aspects of the execution that could be improved. For example, the interviews could have been more extensive. When analysing the results there are areas of interest that could have been explored further. For example, some pupils discussed physics as being difficult and being enjoyable, the two not being mutually exclusive for all pupils. A lack of experience in interviewing was particularly noticeable when the pupils interviewed were less talkative.

Given that the pupils interviewed only attended two schools there are certain variations that have not been investigated. For example there could be further variation if a participant-selection with variation in socio-economic background had been made. Different educational backgrounds among parents might have resulted in some variation on experience with physics.

It is also important to note that while the results provide a clearer idea of how pupils discuss physics and its difficulties, it leaves the question of how to create conflicting discourses and counteract these ideas in the classroom unanswered. Leaving it up to the teachers own ideas and professional experience to act upon it or leaving it as a possible topic for future investigation.

The results provide a snapshot of sorts of how physics is discussed by pupils who are about to embark upon non-compulsory physics courses. A natural future step would be to conduct a similar investigation with pupils at the end of upper secondary school, when they are at the end of their secondary level studies in physics. The results of such an investigation and the results presented here would be a foundation for evaluating how narratives about physics are shaped and formed at upper secondary school.

5.4 Conclusions

Upper secondary school pupils bring with them quite developed and nuanced perceptions of physics from their elementary school studies. In addition to this, physics at upper secondary school is a subject that is discussed among their peers, most often positioned as a difficult subject containing a lot of mathematics. The interviewed pupils position physics in relation to other subjects, how their peers regard the subject as well as the idea of how a person that is good at the subject is. This leads to physics being positioned as a subject that is complex, requires proper understanding, is the foundation to the other natural sciences and a subject that is vague, only for inherently smart people. This positioning results in physics becoming a subject that is difficult due to it being strict, vague and distant as well as being exclusionary. It is a subject that is discussed as not being necessary for everyday life, requiring understanding of how concepts are interlinked and a subject only certain people have disposition for in a way that is difficult to acquire. This gives some guidance for how teachers, especially at elementary school, can approach their physics teaching. However, it only provides a destination in terms of what discourses and ideas to counteract without providing a method or any tools to achieve this objective.

Bibliography

- Adams, W. K., Perkins, K. K., Podolefsky, N. S., Dubson, M., Finkelstein, N. D., & Wieman, C. E. (2006). New instrument for measuring student beliefs about physics and learning physics: The colorado learning attitudes about science survey. *Physical Review Special Topics - Physics Education Research*, *2*(1), 010101. <https://doi.org/10.1103/PhysRevSTPER.2.010101>
- Angell, C., Guttersrud, Ø., Henriksen, E. K., & Isnes, A. (2004). Physics: Frightful, but fun. Pupils' and teachers' views of physics and physics teaching. *Science Education*, *88*(5), 683–706. <https://doi.org/10.1002/sce.10141>
- Archer, L., Moote, J., & MacLeod, E. (2020). Learning that physics is 'not for me': Pedagogic work and the cultivation of habitus among advanced level physics students. *Journal of the Learning Sciences*, *29*(3), 347–384. <https://doi.org/10.1080/10508406.2019.1707679>
- Barton, A. C., & Upadhyay, B. (2010). Teaching and learning science for social justice: Introduction to the special issue. *Equity & Excellence in Education*, *43*(1), 1–5. <https://doi.org/10.1080/10665680903484917>
- Braun, V., & Clarke, V. (2022). *Thematic analysis : A practical guide*. SAGE.
- Bray, A., & Williams, J. (2020). Why is physics hard? unpacking students' perceptions of physics. *Journal of Physics: Conference Series*, *1512*(1), 012002. <https://doi.org/10.1088/1742-6596/1512/1/012002>
- Caspi, A., Gorsky, P., Nitzani-Hendel, R., Zacharia, Z., Rosenfeld, S., Berman, S., & Shildhouse, B. (2019). Ninth-grade students' perceptions of the factors that led them to major in high school science, technology, engineering, and mathematics disciplines. *Science Education*, *103*(5), 1176–1205. <https://doi.org/10.1002/sce.21524>
- DeWitt, J., Archer, L., & Osborne, J. (2013). Nerdy, brainy and normal: Children's and parents' constructions of those who are highly engaged with science. *Research in Science Education*, *43*(4), 1455–1476. <https://doi.org/10.1007/s11165-012-9315-0>
- Dweck, C. S. (2006). *Mindset : The new psychology of success*. (1st ed.). Random House. <https://search.ebscohost.com/login.aspx?direct=true&db=catalog09075a&AN=clpc.oai.edge.chalmers.folio.ebsco.com.fs00001000.740311aa.2f2a.474d.80b0.990e27defe7c&site=eds-live&scope=site&authtype=guest&custid=s3911979&groupid=main&profile=eds>
- Ekici, E. (2016). "Why Do I Slog Through the Physics?" Understanding High School Students' Difficulties in Learning Physics. *Journal of Education and Practice*.
- Erinosh, Y. S. (2013). How do students perceive the difficulty of physics in secondary school? an exploratory study in nigeria. *International Journal for*

- Cross-Disciplinary Subjects in Education*, 3, 1510–1515. <https://doi.org/10.20533/ijcdse.2042.6364.2013.0212>
- God forskningssed* (Reviderad utgåva) [OCLC: 1023073583]. (2017). Vetenskapsrådet.
- Gonsalves, A. J. (2010). *Discourses and gender in doctoral physics: a hard look inside a hard science* [Doctoral dissertation, McGill University].
- Holmegaard, H. T., Madsen, L. M., & Ulriksen, L. (2014). To choose or not to choose science: Constructions of desirable identities among young people considering a STEM higher education programme. *International Journal of Science Education*, 36(2), 186–215. <https://doi.org/10.1080/09500693.2012.749362>
- Johansson, A. (2020). Negotiating intelligence, nerdiness, and status in physics master's studies. *Research in Science Education*, 50(6), 2419–2440. <https://doi.org/10.1007/s11165-018-9786-8>
- Klafki, W. (2000). The significance of classical theories of bildung for a contemporary concept of allgmeinbildung. In I. Westbury, S. Hopmann, & K. Riquarts (Eds.), *Teaching as a reflective practice: The german didaktik tradition* (pp. 85–108). L. Erlbaum Associates.
- Martins, J. S., & Lindsay, W. E. (2022). Evaluation of high school student responses to the colorado learning attitudes about science survey. *Physical Review Physics Education Research*, 18(1), 010132. <https://doi.org/10.1103/PhysRevPhysEducRes.18.010132>
- Nicolaisen, L. B., Ulriksen, L., & Holmegaard, H. T. (2023). Why science education and for whom? the contributions of science capital and bildung. *International Journal of Science Education, Part B*, 13(3), 216–229. <https://doi.org/10.1080/21548455.2022.2155493>
- Ornek, F., Robinson, W. R., & Haugan, M. P. (2008). What makes physics difficult? *International Journal of Environmental & Science Education*, 3(1).
- Osborne, J. (2007). Science education for the twenty first century. *Eurasia Journal of Mathematics, Science & Technology Education*, 3(3).
- Reid, N., & Skryabina, E. A. (2002). Attitudes towards physics. *Research in Science & Technological Education*, 20(1), 67–81. <https://doi.org/10.1080/02635140220130939>
- Schiebinger, L. (1999). Physics and math. In *Has feminism changed science?* Harvard University Press.
- Skolinspektionen. (2010). *Fysik utan dragningskraft* (tech. rep. No. 40-2009:1000). Skolinspektionen. Stockholm.
- Testa, I., De Luca Picione, R., & Scotti Di Uccio, U. (2022). Patterns of italian high school and university students' attitudes towards physics: An analysis based on semiotic-cultural perspective. *European Journal of Psychology of Education*, 37(3), 785–806. <https://doi.org/10.1007/s10212-021-00563-z>
- TIMSS & PIRLS International Study Center. (2016). Student achievement overview - physics [Accessed: 2024-05-13]. <https://timssandpirls.bc.edu/timss2015/international-results/advanced/timss-advanced-2015/physics/student-achievement/#>
- UNESCO. (2021). *Engineering for sustainable development: Delivering on the sustainable development goals* [OCLC: 1246350462].

- Wong, B., Chiu, Y.-L. T., Murray, Ó. M., Horsburgh, J., & Copsey-Blake, M. (2023). 'Biology is easy, physics is hard': Student perceptions of the ideal and the typical student across STEM higher education. *International Studies in Sociology of Education*, 32(1), 118–139. <https://doi.org/10.1080/09620214.2022.2122532>

A

The Consent Form

The following document is the consent form used for gathering participants' consent to participate in the study. The document is written in Swedish.

CHALMERS

Samtycke och information om behandling av personuppgifter i studentarbete

Jag samtycker till att mina personuppgifter i form av

för- och efternamn, ljudupptagning av intervju

får behandlas av Chalmers tekniska högskola för studien:

Undersökning av uppfattningen av och inställningen till fysik bland elever som valt att läsa fysik på gymnasienivå. Syftet med undersökningen är att bilda en uppfattning om elevers inställning och hur de förhåller sig till fysik för att förstå vad de tar med sig för uppfattningar till gymnasiefysiken. Till grund för denna undersökning är intervjuer med gymnasieelever om deras uppfattning av fysik.

Information

Personuppgifterna kommer att hanteras på följande sätt:

Ljudinspelningen kommer att skrivas av (transkriberas) och anonymiseras, så att när man läser avskrivningen av ljudinspelningen ska man inte kunna identifiera vem som har intervjuats. Du kommer att få ett annat namn, en pseudonym, och om det finns en risk att du skulle kunna bli identifierad vid återgivningen av en enskild episod i intervjuerättelsen så kommer den inte att återges i detalj i någon publicering. Uppgifter om dig, som ditt namn, din röst eller andra tydliga uppgifter som kan kopplas till dig som person kommer inte att finnas med i de utskrifter som jag gör eller i presentationen av mitt arbete och examensarbete.

Transkriberingarna kommer att analyseras och ligga till grund för resultatet i rapporten. Innehållet i de anonymiserade transkriberingarna kan komma att diskuteras i processen att genomföra analysen med mina handledare Anders Johansson och Tom Adawi, båda verksamma på avdelningen för Vetenskapens kommunikation och lärande på Chalmers tekniska högskola. Resultatet, inklusive eventuella anonymiserade citat från transkriberingarna, kommer att presenteras i mitt examensarbete som kommer publiceras i Chalmers digitala arkiv för studentarbeten och eventuellt i en vetenskaplig artikel.

Ljudinspelningen och andra personuppgifter kommer att lagras så att inga obehöriga kommer åt dem, och raderas när analys och publicering är klar.

Ditt samtycke gäller tills vidare. Du har rätt att när som helst ta tillbaka ditt samtycke. Detta gör du genom att kontakta mig, Beatriz Bento Hansson, på telefon [telefonnummer] eller mejl bento@student.chalmers.se, alternativt registrator@chalmers.se. Om du återkallar ditt samtycke kommer vi upphöra att behandla personuppgifter vi samlat in med stöd i ditt samtycke. Vissa uppgifter kan komma att sparas pga. Chalmers skyldigheter enligt svensk arkivlagstiftning.

Chalmers tekniska högskola, 412 96 Göteborg, med org. nr 556479-5598 är personuppgiftsansvarig. Du hittar Chalmers integritetspolicy på www.chalmers.se.

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Som registrerad har du rätt att få information om hur dina personuppgifter behandlas. Du har rätt att få felaktiga uppgifter rättade, överflödiga uppgifter raderade, begära att behandlingen begränsas och uppgifter överförda till en annan aktör. Du har även rätt att lämna klagomål till Integritetsskyddsmyndigheten (IMY). Har du frågor rörande Chalmers behandlingar av personuppgifter kan du kontakta Chalmers dataskyddsombud på dataskydd@chalmers.se.

Jag samtycker till att Chalmers tekniska högskola behandlar personuppgifter om mig i enlighet med ovanstående.

Ort	Underskrift
Datum	Namnförtydligande

B

The Interview Guide

The following document is the interview guide the semi-structured interviews were based on. The document is written in Swedish.

Intervjuguide

Beatriz Bento Hansson, läst teknisk fysik och master i lärande och ledarskap på Chalmers. Skriver examensarbete om elevers inställning till fysik.

Syftet med intervjun att utforska dina tankar och upplevelser kring fysik.

Det finns inga rätt och fel svar, är intresserad av hur du tänker och resonerar.

Behöver ej svara alla frågor, avbryta.

Transkribera anonymt, inte kunna veta vem som sa vad.

Några frågor till mig?

Del 1: Uppvärmningsfrågor, bakgrundsfrågor om studier och intressen generellt:

1. Hur skulle du presentera dig själv i några meningar för någon som inte känner dig?
 - a. (Om du skulle berätta några saker om dig själv för någon som inte känner dig, vad skulle du berätta då?)
2. Vad tycker du om att göra på fritiden?
 - a. Vad tycker du om att läsa för böcker/spela för slags spel/se för slags serier/filmer?
 - b. Varför tycker du om att göra det?
3. Vilken grundskola gick du på? [För att säkerställa viss spridning i urval... Borde kanske ligga i introbiten]
4. Hur kom det sig att du valde att studera natur-/teknikprogrammet på gymnasiet?
 - a. Vad var ditt favoritämne i grundskolan?
 - i. Varför tyckte du om det?
 - b. Fanns det något ämne du inte tyckte om?
 - i. Varför tyckte du inte om det?
 - c. Valde dina kompisar från grundskolan att läsa samma program?
5. När du berättar att du läser natur-/teknikprogrammet, brukar folk säga något särskilt om det?

Del 2: Frågor om upplevelser och uppfattningar av fysik:

1. Vad tänker du på när du hör ordet fysik? (Personer, händelser, föremål, fenomen).
 - a. Varför kommer du att tänka på det?
 - b. Var stötte du på det först?
 - c. Vad tycker du om det?
 - d. Vad tycker du om fysik?
2. [Särskilt om du får tunt underlag på frågan innan.] Vad är ditt tidigaste minne av fysik?
3. Vad minns du att ni gjorde på fysiken i högstadiet?
 - a. Eller tidigare än högstadiet om du minns något.
 - b. Vad gick ni igenom för ämnen/områden?
 - i. Vad tyckte du om dem?
 1. Vad gjorde det roligt/tråkigt/intressant/svårt/lätt?
 - c. Gjorde ni några experiment/studiebesök?
 - i. Vad tyckte du om dem?
 1. Vad gjorde det roligt/tråkigt/intressant/svårt/lätt?

- d. (Vad hade du för känslor inför en fysiklektion?)
- 4. Har du någon gång stött på något kopplat till fysik utanför skolan? (Muséebesök, böcker, dokumentärer, filmer)
 - a. Berätta lite mer om det.
 - b. Var det du som valde att se det/gå dit?
 - c. Vad tyckte du om det?
 - i. Vad gjorde det roligt/tråkigt/intressant/svårt/lätt?
 - d. Vad tycker du om fysiken i den upplevelsen i förhållande till fysiken du fick läsa i skolan?
 - i. Är de lika varandra eller inte?
 - 1. På vilket sätt?
- 5. Finns det någon i din familj eller släkt som arbetar med eller är intresserad av fysik?
 - a. Vad gör de/gillar att göra?
 - b. Vad tycker du om det? / Hur verkar det?
 - i. Varför verkar det roligt/tråkigt/intressant/svårt/lätt?
 - c. Hade du velat göra något liknande?
- 6. Om du tänker dig en person som är intresserad av fysik eller arbetar med fysik. Hur skulle du beskriva den personen
 - a. Varför beskriver du personen på det sättet?
 - b. Hur skulle du beskriva den personens personlighet?
 - c. Vad tänker du att en fysiker gör i sitt arbete?
 - d. Behöver man vara smart för att syssla med fysik?
- 7. Vad skulle du säga är syftet med fysik?
 - a. Är det skillnad på syftet med fysik som skolämne och syftet med fysik utanför skolan?

Del 3: Frågor om deras förhållande till fysik:

- 1. Vad tyckte dina klasskompisar i högstadiet om fysik? (Lätt, svårt, tråkigt, intressant)
 - a. Höll du med dem om det? Varför/varför inte?
 - b. Vad brukade de säga om fysik?
 - c. Fanns det någon i din klass som inte höll med?
 - i. Vad tyckte den personen?
 - ii. Vad tyckte andra i klassen om den personen?
- 2. Var dina klasskompisar i högstadiet bra på fysik?
 - a. Hur vet du att de var bra på fysik? / På vilket sätt syntes det att de var bra på fysik?
- 3. Ev.: Var du bra på fysik i högstadiet?
 - a. På vilket sätt märkte du av det?
- 4. Tror du det kommer vara någon skillnad mellan fysiken på högstadiet och fysiken på gymnasiet?

Jag presenterade i början att jag är intresserad av att undersöka vad elever tycker om fysik och framförallt är jag intresserad av vad som får elever att tycka att fysik är svårt.

- 5. Givet allt vi har diskuterat här, skulle du säga att fysik är svårt?
 - a. Varför?
 - b. Vad gör det svårt?

Det var nog alla frågor jag hade. Har du några frågor till mig?

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