Implementing Classroom Differentiation: Bridging the Gap Between Research and Application in Differentiating for Gifted Students.

Thijs Desain, student number 6342361

Master Science Education and Communication, Universiteit Utrecht

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Dr. ir. R.F.G. Meulenbroeks

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Abstract

This qualitative study focuses on the reasons why classroom differentiation for gifted students as a potentially beneficial practice has not seen widespread implementation in secondary education. It aims to uncover underlying problems, e.g. reasons for why teachers lack time to differentiate for the gifted and why they feel ill-prepared to apply differentiation techniques in class. The context is physics secondary education in the Netherlands. Semi-structured interviews with five physics teachers, three university physics teacher trainers, as well as a coach of teachers and a student coach have been conducted. The coded results suggest that teachers need support throughout their career: they need to learn to differentiate their instruction in teacher training, and their school management needs to facilitate and stimulate teachers to do so, as well as to foster a professional climate where teachers learn from each other. Implications for a large-scale quantitative survey among teachers of all subjects in secondary education are proposed and discussed.

Implementing Classroom Differentiation: Bridging the Gap Between Research and Application in Differentiating for Gifted Students.

We all know the smart child in class staring out of the window, since the material they were offered was far below their level. Sadly, this scenario is still a reality for many gifted students. However, there is a lot of recent research on giftedness and the specific needs of gifted learners.

When observing almost any classroom, it becomes clear that not every student is learning optimally. Optimal learning depends on the student's situation, abilities and interests; optimally learning students are learning in a way that motivates and engages them. Furthermore, they are learning in a way that makes use of their personal Zone of Proximal Development (Chaiklin, 2003; Vygotsky, 1978).

This lack of optimal learning is an educational issue, since not learning optimally means that students' preferred levels of Autonomy, Competence, and Relatedness are not met in the tasks they are given. This might in turn decrease their intrinsic motivation (Ryan & Deci, 2000), and can influence their performance in – and perhaps even their choice of – further studies and career (Cerasoli et al., 2014). This is a problem especially for the academically 'stronger' students, for whom the level of the in-class activities and learning goals lies below their Zone of Proximal Development – this group includes, but is not necessarily limited to, gifted learners. Where less academically strong students can often be helped with more guidance within the planned lessons, many of these stronger students need different, more challenging, and especially more complex content, that dives deeper into subject matter than their peers need (Bloom, 1985; Tomlinson et al., 2003; Watts-Taffe et al., 2012).

If the needs of these students are not met, this school experience can lead to low motivation in future work environments as well, when extrinsic motivators (such as grades) are less immediately important. This is a possibility because low intrinsic motivation without sufficient extrinsic incentives has been linked to low performance, and this link is especially robust in people doing quality work (Cerasoli et al., 2014), which is work that involves creativity, cognitive effort, and cooperation. This problem then becomes a societal problem, as quality work is becoming more important in current

society, as it encompasses many jobs that cannot be automated (Frey & Osborne, 2017). The author is of the opinion that if gifted students who would otherwise spend their career doing quality work end up in other fields, our society would then make suboptimal use of the talents and potential of many of its members.

One theoretical approach to solving this problem is to ensure that all students – gifted learners as well as others – are learning within their Zone of Proximal Development while in school. Applying differentiation techniques in the classroom can allow for this. Applying differentiation means that a teacher customizes learning activities to the needs of different categories of students. This can be done on the scale of a lesson segment, a lesson, a period or even the whole curriculum and can be done in terms of content, approach, level, process, or other aspects. If a teacher does this, students who have trouble keeping up receive more explanation and practice, while students who tend to go through the material with ease receive more challenging exercises and additional information. Differentiation can take many forms, but the end result is always a more (but not necessarily fully) personalized learning experience, which can increase intrinsic motivation in students (Tomlinson et al., 2003; Van der Valk, 2014).

Examples of differentiation in the classroom are: letting stronger students skip parts of the homework and assigning them a more challenging bonus paragraph in the textbook instead, and creating two or more separate 'routes' with different levels and complexity from which students can choose for each chapter. Examples of a non-classroom differentiation approach that are used in the Netherlands, are programs where gifted students from different schools follow science modules at a university rather than at school, where they are faced with more challenging and different assignments than in class. One such program is the Utrecht University based UTalent, previously named Junior College (Van der Valk, 2014).

Since stronger students do not need *more* work, but rather *different* work (Bloom, 1985; De Heer, 2017; Tomlinson et al., 2003; Watts-Taffe et al., 2012), it can be harder for a teacher to implement differentiation techniques aimed at these students. For this reason, this research focuses

on implementation of differentiation for these stronger students. While this group is not limited to gifted students alone, the researcher assumes that publications on giftedness education are useful to apply to this entire group (see section 1.1). It should however be noted that it is not feasible for regular schools (with group sizes of 25-30 students) to differentiate on a personal level. Instead, teachers can use a smaller number of routes or groups for each differentiated learning activity (Coubergs et al., 2013; and others).

Academically strong students are hard to cater to for teachers who are not trained to do so. These students are often only a small group within a class and are easily overlooked, as many are able to attain decent grades with minimal effort rather than vocally demanding more challenging work (Betts & Neihart, 1988; Neihart & Betts, 2010). Upon interviewing gifted students (Subotnik et al., 2011) it becomes apparent that differentiation is not effectively used in all classrooms, even though possible interventions and other ways of applying differentiation in the classroom have been studied for decades (Coubergs et al., 2013; Keijzer et al., 2018; Tomlinson et al., 2003; and others). In other words, there is a gap between available differentiation research and interventions and the practical application thereof for gifted and other strong students. This gap is also identified in the American school system by publications like that of Freedberg et al. (2019).

To investigate this gap properly, one could envision a nationwide quantitative study in order to find out where the application of differentiation 'goes wrong'. However, since this is relatively new research territory, especially in the context of Dutch secondary education, there are insufficient grounds upon which to base possible survey items. Some inspiration may be gleaned from Kiley (2011), for example, who writes that American teachers mainly lack knowledge of and training in differentiation. Comparing the Dutch and American secondary school systems is however not entirely possible due to differences in teacher training, school types and curricula. This research aims to explore this subject matter qualitatively, in order to lay the groundwork for subsequent quantitative research, specifically in the context of the Dutch education system. If this gap is more clearly identified, it will

become easier to close it, which means fewer bored, gifted students will have to stare out of windows because they will be busy with engaging and motivating tasks instead.

This research aims to uncover why this gap between available solutions to apply differentiation in the classroom and their practical application exists, and the ways in which it could be bridged. The answers to these questions will be limited to physics education in secondary schools in the Netherlands where the general education and pre-university tracks (Wet op het voortgezet onderwijs, 1963-2020; Nuffic, n.d.) are offered, for reasons of feasibility.

The research question is: *Given the fact that many differentiation options are available to support gifted students, how can Dutch physics teachers be empowered to actually implement these differentiation options?*

In order to answer this question, a number of sub-questions need to be answered with a focus on gifted and other academically strong students:

1. To what extent are teachers prepared and able to apply differentiation techniques and how is this handled in teacher training programs?
2. What types of differentiation are used in practice?
3. What are the main obstacles when attempting to apply differentiation techniques?
4. How can these obstacles be circumvented or removed?

In order to provide explorative answers to these questions, a narrative literature review is presented, in which reasons for and ways to differentiate instruction are presented. Secondly, a qualitative study based on semi-structured interviews with physics teachers, teacher trainers, and coaches of both teachers and students is performed. In this study, the reasons why teachers do or do not apply differentiation in their classrooms are explored.

Chapter 1: Theoretical Background

1.1 What is Giftedness?

Giftedness is hard to define well, though many different attempts have been made. In this study, the very broad definition proposed by Subotnik et al. (2011) is used, which is in part a synthesis of many previously proposed definitions of giftedness:

> Giftedness is the manifestation of performance or production that is clearly at the upper end of the distribution in a talent domain even relative to that of other high-functioning individuals in that domain. Further, giftedness can be viewed as developmental, in that in the beginning stages, potential is the key variable; in later stages, achievement is the measure of giftedness; and in fully developed talents, eminence is the basis on which this label is granted. Psychosocial variables play an essential role in the manifestation of giftedness at every developmental stage. Both cognitive and psychosocial variables are malleable and need to be deliberately cultivated. (p. 7)

In this study, the definition's section on fully developed talents is not relevant, as secondary school students are practically unable to achieve eminence in the field of physics. There might be rare exceptions to this, but in general educational practice teachers only need to be concerned with facilitating part of the step from potential to academic achievement. Furthermore, this research focuses not solely on gifted learners, but also on students who might not be gifted, but are academically stronger than their peers. In practice this total group amounts to about 15-20% of students, or roughly three to five students per class of 25-30 students. This is percentage is chosen for practical reasons: these students can also benefit from the changes made for gifted students, and the bigger group makes implementation of changes that benefit these students more likely.

1.2 Modeling Talent Development

Many models of talent development have been proposed in the past (Bloom, 1985; Gagné, 2005; Renzulli, 2005; and others). Based on these models, Subotnik et al. (2011) synthesized a mega-

model for talent development, which ranges from ability and potential to eminence. In this context, eminence is defined as “contributing in a transcendent way to making societal life better and more beautiful.” (Subotnik et al, 2011, p.7). The present research, as stated before, is only concerned with the first part of this mega-model: the step from ability to competence, from potential to the beginnings of achievement. This selection is made due to the scope of this study: it is simply not realistic to expect students to achieve eminence in any school subject while still attending secondary school, nor to expect secondary school teachers to adequately facilitate this in a classroom setting. It should however be noted that even for these students it will be nigh impossible to fully achieve competence in any field during their secondary education – tertiary education is typically where this can be reached.

The part of the mega-model of Subotnik et al. that is relevant here deals with sparking motivation in pupils, facilitating their use of creativity and fostering their enjoyment of or even love for the subject. Doing so can possibly lift the students from showing potential to achieving competence and, eventually, even eminence. Subotnik et al. (2011) use the word competence in this mega-model to mean something different than the Competence aspect of intrinsic motivation that Ryan and Deci (2000) identify. Here, competence is one of the steps in a gifted learner’s path from showing potential to achieving eminence in a field. This competence is the level that gifted students develop in relation to peers in secondary and tertiary education.

1.3 The Background and Context of This Research: The Zone of Proximal Development

Since every model for talent development and differentiated instruction relies on and aims to get students into their Zone of Proximal Development, it is necessary to elaborate on this concept.

The Zone of Proximal Development is “the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers” (Vygotsky, 1978, p. 86). In other words, the Zone of Proximal Development signifies the difference between what a learner can currently achieve versus what a learner can just barely reach with proper guidance.

In this study, 'within the Zone of Proximal Development' is used when a student is learning in such a way that near-optimal use is made of their Zone of Proximal Development. When this is done, the student will reach this potential development level from their current development level much faster than when the student learns closer to their current actual development level than their Zone of Proximal Development allows for (Chaiklin, 2003).

This means that academically stronger students need to be given tasks that are beyond the standard school curriculum in order for them to keep developing mentally at their ideal rate and in order for them to continue to be mentally stimulated and motivated. The Zone of Proximal Development also means that these students cannot simply be given a paper to read or a keyword to look up, as happens too often (De Heer, 2017). They truly require guidance (in the form of extra lessons, well-written exercises, or in a team with peers of different levels but similar ambitions and needs) in order to learn optimally. Additionally, the self-determination theory by Ryan and Deci (2000) should be included. This theory poses that three important factors help foster intrinsic motivation: Competence, Autonomy and Relatedness. A student will generally become more motivated for a task if it is neither too easy nor too hard for them (Competence), if they have an appropriate amount of choice during the process (Autonomy) and if they feel respected by their instructor (Relatedness). This situation bears a close likeness to the situation of learning 'within the Zone of Proximal Development' described above. The terms Competence, Autonomy and Relatedness are capitalized here to distinguish Competence in this context from the notion of competence used in section 1.2.

1.4 Underperformance

Underperformance or underachievement is what happens when a student's achievement in a subject – generally an academic one – is less than could be expected based on their perceived potential (Peters, 2012). In order to provide appropriate development of the talents of students, underachievement is something teachers should aim to prevent or minimize.

Peters (2012) observes that the existence of the term underachievement must imply that these subjects are “worth achieving at.” This means that an underachieving student might simply not see or agree with the value of the subject matter. A way to prevent or remedy this is to instill a sense of value of the subject matter in students. Peters (2012) states that this can be done by teaching in an engaging way and at appropriate levels, whilst encouraging evaluation of what is being taught. In addition to this, teachers should take into consideration the individual situation of underperformers (Ritchotte et al., 2015) as well as their individual motivations and interests (Cavilla, 2015). Much of this is in line with the characteristics of differentiation mentioned in section 1.6. In other words: it seems that differentiated teaching might help prevent and even remedy underperformance in students. The necessarily individual nature of underperformance prevention and remediation that Cavilla (2015), Peters (2012), Ritchotte et al. (2015) propose is also echoed the description of what highly differentiated teaching looks like, as described by Coubergs et al. (2013).

1.5 Why Differentiate Instruction?

If a teacher aims to enable students to learn within their Zone of Proximal Development, they must provide different instruction to their academically stronger pupils than to their average pupils, who in turn need different instruction than their academically weaker pupils. Taking into account the differences of students necessitates differentiated lessons (Tomlinson et al., 2003).

Additionally, Van der Valk (2014) states that without appropriate differentiation there is no guarantee that students are prepared for tertiary education. Since grades only show the end result of a student’s learning without giving insight into their learning abilities and study skills, students with lower grades who are well versed in study skills can often have more success in tertiary education than their peers who achieve high grades without effort. By differentiating instruction, a teacher can aid all students in developing these abilities and skills.

Differentiation is often merely focused on the weaker students, those who need additional instruction. According to De Heer (2017), this is due to notions that are widespread in Dutch society –

but not limited to the Netherlands (Subotnik et al., 2011) – that the extremes need not be catered to, and that the average should be the focus and the goal. These notions are, according to De Heer (2017), a major obstacle to the implementation of differentiation in primary education. The researcher hypothesizes that this might also hold for secondary education, since De Heer shows that these ideas are held widely and have been for decades, including by high-level policy makers.

1.6 What Does Differentiated Learning Look Like?

Gifted students, as well as otherwise motivated students, have a number of preferences concerning the nature of tasks they do within a school context. Kanevsky (2011) writes that these students want more control over the pacing and content of their tasks than the average student, as well as more control over the methods they use and who they collaborate with. Furthermore, gifted students prefer complex tasks that involve connecting different ideas and areas of knowledge. In this 2011 article, Kanevsky makes the point that this research indicates that there is no essential difference in tasks preferred by either gifted or non-gifted students, the difference is one of degree. In other words: all students benefit from doing a complex task every now and then, but stronger students want them more often.

Bloom (1985) concludes, based on a number of case studies of gifted people, that teaching these people will be more effective and will yield more success if this teaching meets the following four requirements:

- It is focused on larger patterns and processes,
- It allows students to discover knowledge rather than just to process it,
- It allows for solution methods other than the one the teacher expects, and
- It focuses on student progress and improvement rather than on grading.

These indications for effective teaching go hand in hand with the students' preferences reported by Kanevsky (2011) – it seems that what students want, overlaps with what students need.

In a similar vein, Tomlinson et al. (2003) state that differentiation must be proactive and pre-planned. This is underlined by Watts-Taffe et al. (2012), who also prescribe that effective differentiated instruction must be personalized to some extent, which means that a teacher must know their students' needs and interests as well as monitor their progress. By doing the latter, the teacher can make effective and appropriate decisions for the students' instructions.

Various aspects of teaching can be differentiated. The five aspects of lessons and curricula that are typically differentiated (Coubergs et al., 2013; Keijzer et al., 2018) are presented in Table 1.

Table 1

Five types of differentiation with examples.

Type of differentiation	Example
Differentiating by level	During an experiment, the teacher gives different instruction sheets to different students: some get a clear list of step-by-step instructions, while some more advanced students get open questions with fewer intermediate steps.
Differentiating by tempo	Some of the classroom instruction is optional: at a certain time in a lesson, students can choose to receive more interactive instruction from the teacher. The other option is to already start solving exercises related to the lesson topic.
Differentiating by process	Students can choose two ways to prepare for a lesson: they can either read a section of the coursebook or watch a video in which the same theory is explained.
Differentiating by product	After a research project, some groups give a presentation, others hand in a report, and one group even shows a short film of their findings.
Differentiating by learning style	The teacher offers two routes for test preparation: students may either start with a practice test and attend a question-and-answer session later, or they may start with reviewing the theory and doing the practice test second.

*Note. B*ased on Coubergs et al. (2013) and Keijzer et al. (2018).

One way of designing differentiated instruction is through the use of Whole Task First (*hele taak eerst*), which is what Janssen et al. (2016) call the process of starting with the final task of a lesson or lesson series, which allows for more Personalized Assistance from the teacher (*hulp op maat*). In their 2016 publication, Janssen et al. describe this method and give clear examples and suggestions for

each Dutch secondary school subject. One of these examples for a physics course is presented in Appendix A.

Other practical tips for differentiating lesson content are given by, among others, Bruggink (2017) and Keijzer et al. (2018). These are accessibly written books with concise tips and learning activities that are easy for teachers to use and are rooted in scientific literature. Books like this make effective teaching more accessible, since it allows teachers to spend less time reading academic publications and more time preparing effective, differentiated lessons. Other practical sources for teachers are non-academic articles like “Common Sticking Points About Differentiation” by Tomlinson and Imbeau (2012), in which often-raised objections are refuted concisely and in a practically useful way. These are the sources that need to be readily available to teachers, as they exist to bridge the gap between scientific research and the classroom practice.

1.7 Framework for Describing Teacher's Use of In-Class Differentiation

In addition to their mega-model, Subotnik et al. (2011) provide a research agenda for the field of talent development research. To do so, they divide students into four quadrants based on their situation, and suggest potential research avenues for each of these quadrants (see Table 2).

Table 2.

Achievement as a function of high versus low motivation and high versus low opportunity.

	Low Opportunity	High Opportunity
High Motivation	Enhanced likelihood of eminent outcome with teaching resources and insider knowledge plus appropriate educational dosage, psycho-social supports, and environmental supports Most important societal responsibility	Greatest likelihood of eminent outcome with appropriate educational dosage, psycho-social supports, and environmental supports Best "bang for the buck"
Low/Undetermined Motivation	Outcome depends on provision of opportunities to reveal interests and abilities and enhance motivation Greatest challenge to society; worthy of investment in opportunity With opportunity, motivation may or may not develop	Eminence not likely unless motivation is enhanced by programs that assist with changing mindsets and matching to appropriate domains and mentors Limited investment to generate motivation

Note. This table is paraphrasing Subotnik et al. (2011, p. 36).

In the present study, this division of students is adapted into a guiding frame to describe teachers' use of differentiation techniques in the classroom (see Figure 1). This guiding frame is used to picture the various differentiation-related situations teachers can find themselves in.

An example teacher in the top right quadrant is highly motivated and has ample opportunity to apply differentiation techniques in the classroom. Such a teacher may have worked together with their colleagues to build multiple levels of differentiation into their subject's entire program. Alternatively, such a teacher may have – or may have had – the time to create a large number of high-level alternative assignments that can be given to students as the teacher sees fit.

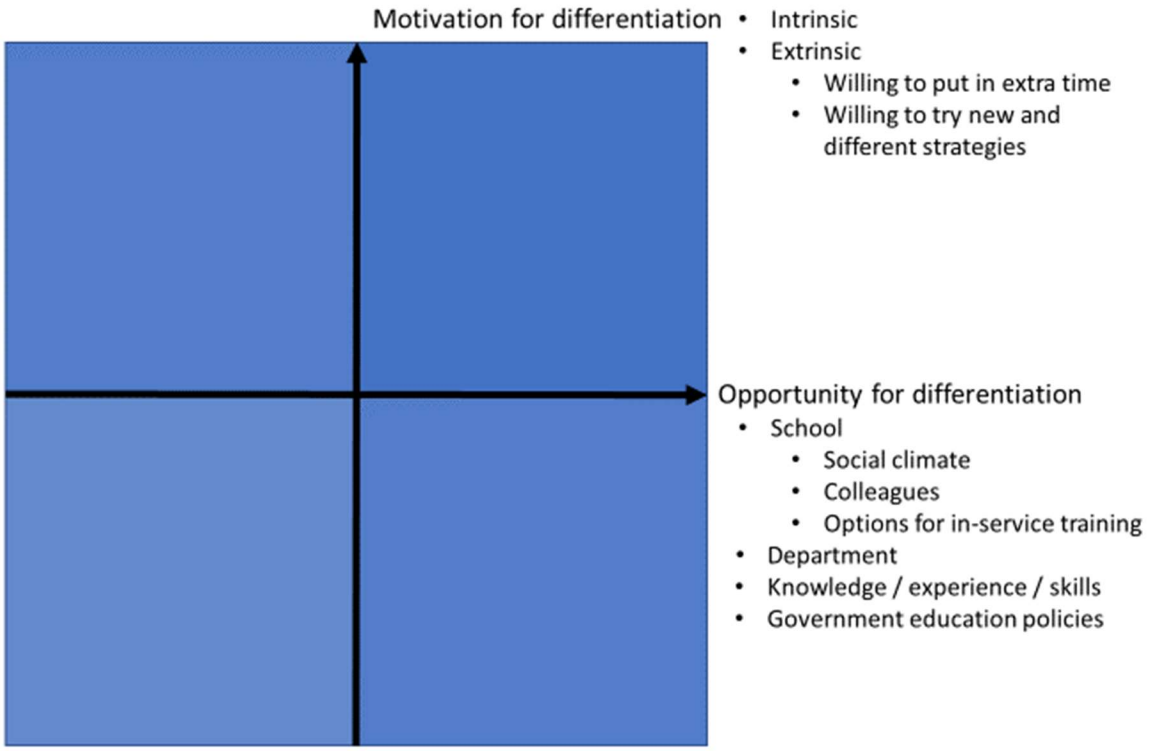
An example teacher from the top left quadrant wants to incorporate differentiation techniques into their lessons, but is not given the time to do so by external factors – they could be stuck with too many administrative tasks, or have too many classroom hours to spend enough time on preparation of differentiation techniques.

Teachers from the bottom half are not quite interested in putting in the time to find, create and/or apply differentiation techniques for their gifted students. Reasons for this might be:

- They prioritize spending time on getting weaker students to a higher level of performance,
- They use their time outside of the classroom for other projects within the school,
- They are under the impression that 'these kids are smart, they can figure it out on their own' (De Heer, 2017).

Figure 1.

A model to plot teachers' opportunity and motivation for applying differentiation.

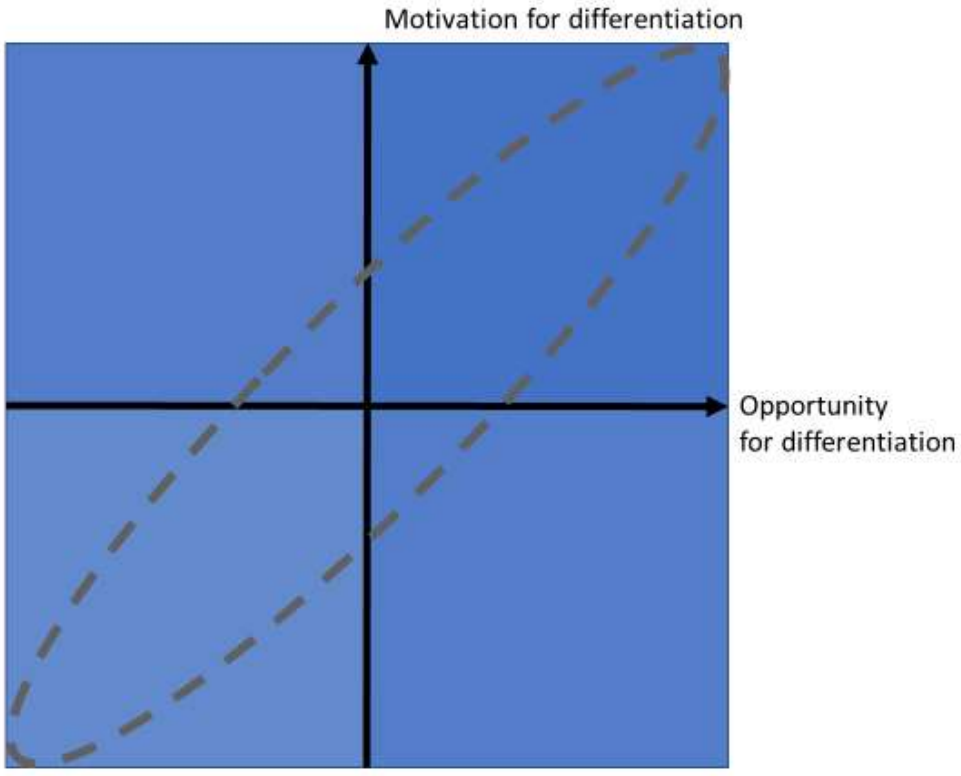


Note. This model is adapted from Subotnik et al. (2014, p. 36).

This study theorizes that many teachers will find themselves along the diagonal of this diagram, as illustrated in Figure 2. This hypothesis is supported by Hawkins (2009), who writes that one of the main obstacles to differentiated teaching is a lack of efficacy, confidence and perseverance in teachers. Dixon et al. (2014) reframe this in a more positive way: they state that higher teacher efficacy is linked to a higher likelihood of differentiated teaching. Teacher efficacy is the confidence of teachers in their ability to teach effectively and promote learning in their students. This can and should be stimulated to grow, e.g. through workshops that schools offer as in-service training. In short, Dixon et al. (2014) state that good teachers who know they are good are more likely to apply differentiation and vice versa. In terms of the model this summary becomes: teachers with high opportunity become more motivated to differentiate. Freedberg et al. (2019) and Kiley (2011) confirm that a lack of knowledge and training in teachers, which amounts to a lack of teacher efficacy, is indeed a major reason for the lack of differentiation implementation by teachers in the United States of America.

Figure 2.

Hypothesizing the locations of most teachers in the model of Figure 1.



Combining this model with the literature presented in the previous sections of this chapter, the author hypothesizes that teachers who do not differentiate much of their education, but wish to do so, should increase their teacher efficacy, which can be done formally by attending in-service training and participating in workshops, as well as less formally by observing and exchanging ideas with colleagues who already operate within the upper right quadrant of the model. This is in agreement with the findings of Latz et al. (2008), who suggest that by increasing teacher efficacy through peer coaching, teachers increase their ability to implement successful differentiation techniques and do so more frequently than before this peer coaching.

Chapter 2: Methods

2.1 Introduction

The research questions are answered exploratively, based on three sets of semi-structured interviews, each with different question lists. The first set of interviews was done with teacher trainers from three Dutch universities. The second set was conducted with one coach from in-service training programs on differentiation for teachers and one coach of gifted students. For the third set of interviews, five physics teachers from secondary schools (in the general education (havo) and pre-university (vwo) tracks) were interviewed. These three categories will be explained further in the following sections. Each interview was recorded to facilitate computer-aided transcription, for which verbal consent from the interviewee was given, on the condition that the finished transcript would be sent to the interviewee for transparency.

After a pilot interview with one of the teachers, the teacher trainers were interviewed first. This was done in order to interview the teachers within the context of what knowledge and skills new teachers are – or will be – equipped with. After coding, the answers of each of the three sets of interviewees were compared using a bottom-up, emergent coding method. These comparisons helped to identify mismatches between the answers of teachers and teacher trainers – e.g. whether teachers use differentiation in the way they are taught by teacher trainers, or if they instead (want to) use different techniques. The translated interview question lists for each category can be found in Appendix B – Interview Schemes.

2.2 Interviews With Teacher Trainers

To explore the knowledge and skills pertaining to differentiating instruction that new physics teachers start their careers with, the researcher has interviewed teacher trainers from three Dutch universities. These universities each have full teaching degree programs (in Dutch: *eerstegraads* qualification, which allows a teacher to teach the final years of the general education (havo) and pre-university (vwo) tracks). The chosen institutes were University of Amsterdam, University of Twente,

and Utrecht University. These universities have been chosen for pragmatic reasons, but were also selected to include universities from different regions of the country. Two of these teacher trainers teach physics didactics, the third teaches biology didactics. The teacher trainers had three, ten, and fifteen years of experience, respectively. The questions in these interviews focused on the Opportunity axis of the model presented in section 1.7, including questions about available elective courses on differentiation and talent development and the incorporation of these topics into the mandatory teacher training curricula.

One of the interviews took place via an online audio-call, the other two took place in the respective offices of the interviewees; all three were conducted without others present. The interviews lasted between 15 and 33 minutes. One teacher trainer also provided additional information via email after the interview. This information was considered as part of the interview and was coded as such.

2.3 Interviews With Coaches

The researcher has interviewed two coaches. The first coach gives in-service trainings on differentiation to teachers, helping them to increase their knowledge and skill concerning classroom differentiation and talent development. This person was selected based on their 22 years of experience as well as for pragmatic reasons. The second is a coach of gifted students, who was interviewed to provide a student perspective on. This person aids gifted students who have trouble adapting to average heterogenous classrooms and had nine years of experience. This second coach is also a secondary school teacher, teaching classical languages (Latin and ancient Greek) and was selected for pragmatic reasons: the researcher knows this coach personally.

These interviews provide insight in how current teachers can improve their differentiation knowledge and skills – and therefore to increase their Opportunity. The interviews included questions on what these coaches see teachers are struggling with and on how the available research can be implemented successfully.

Both interviews were conducted in the respective interviewees' homes, without others present and lasted between 35 and 60 minutes. The in-service training coach provided additional information via email after the interview was conducted. This information was considered as part of the interview and was coded as such.

2.4 Interviews With Teachers

Five interviews were conducted with physics teachers, who were selected with the aim to cover each quadrant from the model in Figure 1. The teachers either had a full teaching degree or were in the process of getting this qualification and were teaching at this level. Their teaching experience – ranging from less than a year to two and a half decades – was not taken into account in data analysis. Two of the interviewed teachers were female and three of them were male. The teacher with whom the pilot interview was conducted, was selected based on their ties with the Utrecht University UTalent program. The other four teachers were selected from the extended personal network of the researcher and all taught at schools in different cities.

The guiding frame from section 1.7 was not discussed explicitly in the interviews, but based on statements given in these interviews, the following assessment can be made. Of the five teachers, one openly and consciously does not use differentiation techniques, which puts this teacher in the low Motivation, High Opportunity quadrant. The other four all strive to be in the high-Opportunity, high-Motivation quadrant of the model. These four teachers can therefore be placed in the top half of the guiding frame.

One interview was conducted in the teacher's personal office at Utrecht University, two were conducted at an institution for teacher training and two were conducted at the schools where the teachers worked. The interviews lasted between 16 and 28 minutes.

2.5 Data Analysis

The interviews were conducted, transcribed and coded in Dutch. The key quotes presented in this research were translated to English. The audio of each interview was recorded. Based on these recordings, transcripts were made by correcting an automatic transcript created using KALDI Automatic Speech Recognition.

To ensure validity, the following process was used for creating a list of questions and the coding scheme. Based on the literature presented in Chapter 1 and on the researcher's intuition, a preliminary question list was created. These preliminary questions were tested in a pilot interview with one of the teachers. After this pilot interview, it was not deemed necessary to alter the question list for teacher interviews. The question lists for the interviews with the teacher trainers and the coaches have not been subjected to a pilot interview, as these groups of respondents were too small to warrant a pilot interview. All of the final question lists can be found in Appendix B – Interview Schemes.

Each interview transcript was presented to the interviewee for approval prior to analysis. The order and precise wording of the questions asked varied somewhat between interviews, but during each interview within a category each question from the list was asked.

The coding schemes for each set of interviews aimed to find where the gap between theory and practical application originates and what can be done to bridge this gap – what do teachers need, what do teachers receive, and what stops teachers from applying the theory? This was done through a bottom-up coding process. First, the research questions were used as initial codes, sorting meaning units based on which of the question(s) they answered. The five initial codes used were:

- How do teacher trainers handle differentiation?

  (This code was not used for teacher interviews)
- To what extent are teachers equipped with knowledge regarding differentiation?

  (This code was not used for teacher trainer interviews)
- What types of differentiation are used in practice?
- What are the main obstacles when attempting to apply differentiation techniques?

- How can these obstacles be circumvented or removed?

The initial coding of the pilot interview was verified by a second rater; this resulted in a near perfect interrater agreement, Cohen's $\kappa = 0.94$. There was only one case of disagreement, where the second rater assigned two codes to one meaning unit, where the researcher had only assigned one of these codes. The second rater fully approved of the coding method used. Based on this initial coding, the researcher identified and labeled emerging themes from the meaning units. These themes were used as the final, emergent codes. These themes are reported as the results of this study in chapter 3.

Chapter 3: Results

3.1 Introduction

For each research question and each of the three groups of interviewees, the major theme or themes of the interviews are listed in Table 3. These themes are illustrated with a characteristic quote and are tallied: both the total amount of times a theme was mentioned and how many interviewees of that category mentioned the theme are presented. The recurring themes are named using bold print, these names are also used as the entries in Table 3. The results are ordered according to the subquestions to the main research question.

The themes reported here include both broad themes that many interviewees put forward and narrow themes that were talked about only by one or two interviewees, but were mentioned multiple times. Since this study has a very small sample size, themes that are important to even a single interviewee are considered relevant to consider within the scope of this study.

3.2 To What Extent Are Teachers Prepared and Able to Apply Differentiation Techniques? How is This Handled in Teacher Training Programs?

Most of the teachers agreed that differentiated teaching is important (this came up eight times, from four teachers), but they learned – and are still learning – how to do this by trial and error rather than based on a theoretical foundation. In Table 3, this is labeled **Learning by doing**, which was mentioned three times by three teachers. One of the coaches agreed with this, stating three times that teachers need more theoretical support as well as practical – in Table 3 this is labeled **Insufficient teacher efficacy**.

According to teacher trainers, differentiation has a low priority in the curriculum for student teachers. This theme is labeled **Little focus on differentiation** in Table 3 and has three main reasons behind it, as reported by the teacher trainers:

- The teacher training curriculum is very full: the full teaching degree program only lasts one year, and there are too many learning goals to be achieved.

- There are very few physics teachers in training. Most Physics Teaching Methodology classes have between four and ten student teachers, and sometimes only one. This means that giving differentiated instruction in a form that translates to the regular classroom (applying the motto “teach as you preach”) is nigh-impossible.
- There are other teaching skills that are considered more important or fundamental, and must be addressed first. The most prominent example of this is classroom management.

The third reason is not unanimously shared among all teacher trainers. While this theme was mentioned four times by two of the teacher trainers, two teacher trainers – one of the two who mentioned this theme and the third – put forward that differentiation can and should be integrated into the teacher training curriculum. This came up four times.

One of the coaches disagrees with this third reason too. They made it clear, twice, that by teaching differentiated lessons, classroom management becomes easier. This mistaken deprioritizing of differentiation is labeled **Other skills considered to be more important** in Table 3.

3.3 What Types of Differentiation Are Used in Practice?

The main theme put forward by both teachers and coaches is that there is a **Large range of options**. One of the coaches summarized this by stating that there is not one best way to differentiate instruction, but there are the best teachers who employ it. In other words, a good teacher who knows what they are doing is more important than which learning activities they use. The teachers provided a different interpretation of the theme: they put forward that knowing that differentiated instruction can be “small” is very comforting. By “small”, they meant that it can be limited to one learning activity or one lesson, and that it need not necessitate a full subject curriculum overhaul. This theme was mentioned explicitly by one coach once, three times by two teachers and once by one teacher trainer. It was implicitly alluded to by others as well.

Another theme that was put forward – two times, by one teacher – was the **Macro-level differentiation** that is present in the Dutch school system. Around age twelve, Dutch children are

differentiated into three main school types with several subtypes (Wet op het voortgezet onderwijs, 1963-2020; Nuffic, n.d.), ranging from a more practical focus to a more theoretical, pre-university one. This already lowers classroom heterogeneity. One teacher also mentioned that in most schools, students see multiple teachers a day, each with a different style of teaching. According to this person, this means that there already is a lot of variety in how students are engaged each day.

Aside from these two main themes, a large number of examples of differentiation were mentioned across all interviews, covering all aspects of differentiation listed in Table 1. A detailed list of these examples is available in Appendix C. The examples of differentiated instruction that were mentioned the most often were the following:

- Three teachers mentioned a total of four times that they like to make central instruction optional. This means that the students who choose not to engage with the instruction are then working on the assignment or exercises which the instruction will explain. This is a way of differentiating by level and by pace.
- Four teachers mentioned once each that they sometimes hand out two or more levels of worksheets to students. This can be done for test preparation material, for practicals or even for entire chapters. This is a way of differentiating by level, with possibilities for differentiating content and process as well.
- Two teacher trainers mentioned Whole Task First with Personalized Assistance (*hele taak eerst met hulp op maat* (Janssen, 2016)) a total of three times, in the context of having applied this as a teacher and teaching it to their students. This is a differentiation philosophy or a lesson design skeleton rather than a specific example, and any type of differentiation is possible with it.

3.4 What Are the Main Obstacles When Attempting to Apply Differentiation Techniques?

The main theme that came forward in most interviews is the **Rigid mandatory curriculum**, or the **Perceived rigidity of the mandatory curriculum** by the teachers. This was mentioned twice by two

of the teacher trainers, six times by four teachers, and four times by both coaches. The curriculum rigidity these people allude to is the fullness of the mandatory schedule of secondary education: at the end of their career in secondary school, pupils need to have met a list of government-mandated learning goals. These learning goals can be found on the Dutch government website Examenblad.nl (College voor Toetsen en Examens, n.d.), where the mandatory curriculum can be retrieved for each school type, year and subject. Teachers feel that these mandatory learning goals dictate “95%” of what they can do in their lessons, as a teacher trainer worded it.

This theme is closely related to the theme **Differentiation is perceived as hard**, which was mentioned twice by two teacher trainers, six times by five of the teachers and once by one of the coaches. Together, these themes describe factors that inhibit teachers’ ability to differentiate their instruction, which are potentially solvable and are intrapersonal, unlike the other factors mentioned below. A possible solution is pointed at by the coach who raised this theme, as this person stated that the rigidity of the school curriculum is partially real and partially perceived. The teachers’ frame of mind, according to this coach, must be allowed to change to one where teachers dare to let go of the coursebook and find creative ways to combine learning goals in other assignments and projects.

A theme that was brought forward by one teacher, but deemed important enough by this person to mention it six times, was that differentiation **Doesn’t fit [their] personal teaching style**. In other words: if a teacher discovers that their teaching is negatively impacted by differentiation attempts and if their teaching is otherwise viewed as effective and “good” by colleagues and students alike, that teacher should not be forced to differentiate their instruction.

A theme that was put forward twice by one coach is the **Lack of school board support**. What this coach described with this theme is the need for the management and board of a school to support teachers in their growth as differentiating teachers. This ranges from facilitating and stimulating in-service training to spotlighting innovative work of teachers who are already differentiating their instruction. This theme is related to another inhibiting factor, raised once by the same coach and twice in total by two teachers: the available facilities and rules around them, for which the school board is

responsible. This entails whether or not teachers are allowed to let groups of students work outside of the classroom, what digital or online tools are available for use, which electronic devices can be used in the classroom and more. A wider availability of these facilities and teachers' freedom to make use of them might positively impact the use and success of differentiated instruction.

3.5 How Can These Obstacles be Removed?

The teacher trainers were all in agreement: **Teacher training must also be differentiated** and the teacher training programs must **Prioritize differentiation**. In short, differentiation should be integrated in the teacher training curriculum (both themes were mentioned four times by all three teacher trainers). This is summed up concisely by the phrase "teach as you preach" – which was echoed by one of the coaches. This tenet means that differentiation should not just be taught, but also applied in teacher training: if new teachers start their careers having experienced differentiated instruction themselves, they might be better equipped to apply it in their own practice. This experience will also give new teachers a number of concrete examples they can draw upon in preparing their own lessons.

Beyond teacher training, the most practical way in which teachers can get used to differentiating their lessons is through doing: **Practice makes perfect**. This was said three times by two teachers, as well as six times by both coaches. In order to collect ideas and options to practice in this way, two teachers suggested once each that they try to **Learn from peers** by exchanging ideas with colleagues or by observing colleagues at work.

Finally, there needs to be a certain frame of mind among teachers, which entails that students and their learning are at the center of education. One aspect of this is that teachers **[shouldn't] be afraid to learn from students** (this was mentioned four times by both coaches): sometimes students will know more of a certain topic than their teacher, or they will ask a question that the teacher doesn't know the answer to. It is highly important that teachers stimulate and foster this, rather than suppress it with answers like "you'll find out next year, when we cover that subject" or "you don't need to know that". If teachers foster this inquisitiveness in their students, these students will be more motivated to

keep learning. This is especially pronounced when a teacher helps a student with such a complicated question to research the answer – the teacher may not know the answer, but will generally know more of finding, evaluating and interpreting sources than their students do.

Table 3.

A summary of the results of this research project.

	Teacher trainers		Teachers		Coaches	
1. To what extent are teachers prepared and able to apply differentiation techniques? How is this handled in teacher training programs?	**Little focus on differentiation** "We need to cover so many things, that the little time we spend on differentiation is the maximum amount we can manage."	6/2	**Learning by doing** "Sometimes you read some tips, or a learning activity you think you'll like, and then you try it out."	3/3	**Other skills considered to be more important** "There's a conviction [among teacher trainers] that a number of other fundamental skills need to be addressed first [before you get to differentiation, but] if your lessons aren't interesting to students, of course you'll get unruly classes!"	2/1
					Insufficient teacher efficacy "Teachers observe others applying [differentiation], but they have no clue how to use it themselves."	3/1
2. What types of differentia-tion are used in practice?			**Large range of options** "Differentiation doesn't need to be a rigorous, high-level endeavor, it can also be a small and simple learning activity."	3/2	**Large range of options** "There isn't one best way to differentiate, there are the best teachers."	1/1
			Macro-level differentiation "We already have a very differentiated education system. We're putting children into categories at age twelve."	2/1		

	Teacher trainers		Teachers		Coaches	
3. What are the main obstacles when attempting to apply differentiation techniques?	**Rigid mandatory curriculum** "Teachers feel that the mandatory curriculum dictates 95% of what they can do."	2/2	**Rigid mandatory curriculum** "Finishing the mandatory subjects already is a race against the clock."	6/4	**Perceived rigidity of mandatory curriculum** "Teachers must not be afraid of change, they must be creative in designing their lessons, they should not fear letting go of (part of) the coursebook's schedule."	4/1
	Differentiation is perceived as hard "Some teachers also teach [product design courses], where they find it very normal that every group of students is doing something else, while they teach undifferentiated physics classes on the same day."	2/1	**Differentiation is perceived as hard** "In my experience it's quite hard to determine where everyone is at, to discriminate and then divide my attention"	6/5		
			Doesn't fit personal teaching style "It doesn't align with the way of teaching I find comfortable."	6/1	**Lack of school board support** "The school board has to make sure teachers are able and encouraged to differentiate their teaching."	2/1
4. How can these obstacles be removed?	**Teacher training must also be differentiated** "Teach as you preach."	4/3	**Practice makes perfect** "It's a matter of experience. When you have that, differentiating becomes easier."	3/2	**Practice makes perfect** "Apply it, use it, try it, make it yours."	6/2
	Prioritize differentiation "I'd love to see differentiation be taught earlier on in Teaching Methodology."	4/3	**Learn from peers** "Something I do a lot is looking at what others are doing and using that inspiration in my own lessons."	2/2	**Don't be afraid to learn from students** "Listen. Ask open questions. Do not be offended if a student knows something better than you do."	4/2

Note. For each of the twelve categories, themes are illustrated with characteristic quotes and marked with how many times and by how many interviewees the theme was put forward. For example: 6/2 means 'mentioned six times by two people in the category'

Chapter 4: Conclusions

4.1 Introduction

In this section, the findings from the theoretical background and the interviews will be discussed in order to answer each of the four subquestions, after which the main research question will be answered.

4.2 To What Extent Are Teachers Prepared and Able to Apply Differentiation Techniques? How is This Handled in Teacher Training Programs?

Teacher training does not adequately prepare student teachers to differentiate their instruction; current teachers learn by doing, but often lack the necessary teacher efficacy. Two main reasons for the lack of adequate preparation in teacher training programs are the full teacher training curriculum and the fact that some teacher trainers see differentiation as an advanced skill.

This conclusion is based on two of the main themes that arose from the interviews. The first is that there is a difference of opinion between two of the teacher trainers on one hand and a coach and the third teacher trainer on the other. The first two teacher trainers state that it's correct to focus on other aspects of teaching instead of on differentiation. The coach and the third teacher trainer disagree: they state that this should change and that differentiation should be integrated in the teacher training curriculum – rather than devoting one or two classes to the topic, the teacher training program itself should be differentiated.

This is not easy, however, for two main reasons. Firstly, the groups of starting teachers in courses like Subject Teaching Methodology for science subjects rarely have more than ten participants. Secondly, the teacher training curriculum is very full and is to be completed in only one year. Because of these reasons, there are many types of differentiation teachers might want to use that aren't practical or possible to use in teacher training.

The second main theme is that the teachers state that they learned most of what they know of differentiation by doing and trying. The coaches add that teachers also lack the teacher efficacy to bring what they know into practice effectively.

4.3 What Types of Differentiation Are Used in Practice?

Aside from macro-level differentiation inherently present in the Dutch school system, many types and forms of classroom differentiation are used. Of these types and forms, there is no best option. It is the way in which these options are implemented that determines the success and effectiveness of a differentiation technique. Of each type of differentiation mentioned in Table 1, at least one example was given; all examples are listed in Appendix C.

Aside from these examples, two main points were put forward during the interviews. Firstly, interviewees from each category agreed that there is a large range of differentiation options and that there is no such thing as the best way or the correct way to differentiate instruction. The way a type or form of differentiation is implemented is more important than the method chosen. Secondly, it was pointed out that the Dutch school system is already differentiated in many ways on the macro-level.

4.4 What Are the Main Obstacles When Attempting to Apply Differentiation Techniques?

The main obstacles brought forward in the interviews are the perceived rigidity of the secondary education physics curriculum, a lack of school management support, and a missing student-focused frame of mind.

The main obstacle the physics teachers see is that they view differentiating instruction as hard and as time-consuming. This goes hand in hand with the obstacle that is the school curriculum, which is seen as very rigid and binding, seemingly leaving little room for differentiation. These obstacles are put forward by both teachers and teacher trainers. The coaches, however, state that this is mainly a problem of perception: by doing and learning, teachers will see that there is plenty of room for differentiation, even within the limits that time and school curriculum pose.

Lessening this perception that differentiation is difficult goes hand in hand with a frame of mind that should, according to coaches, become more prevalent. This frame of mind is student-focused: the teacher's role should be to help students learn and gain knowledge, rather than to impart knowledge and a specific way of reasoning upon students. It is also important that teachers listen more to students and their wishes than they currently do. This holds especially for gifted and academically strong students.

According to both coaches and teachers, another obstacle that teachers often run into is a lack of support from school management. This entails stimulation to attend in-service training as well as allowing teachers the freedom to let students work outside the classroom, for example. Providing students and staff with up-to-date computer devices and software is also seen as an important need.

However, not all teachers are comfortable with teaching differentiated classes, even if they work in an environment that provides ample opportunity to do so. One of the interviewed teachers found, after much trial and error, that their lesson quality and the enjoyment of both themselves and their students lessens when they differentiate their lessons: it is simply not a teaching style that works for them.

4.5 How Can These Obstacles be Removed?

The main obstacles to implementing classroom differentiation can be removed by increasing teacher efficacy, which is achieved through differentiated teacher training, support from school management, and learning by doing, learning from peers and learning from students.

Teachers must increase their teacher efficacy if they want to differentiate more. In order to facilitate this, the teacher training programs should not just prioritize the topic of differentiation, but they must also differentiate their own curriculum. By doing this, student teachers will experience how differentiation works from the student side and will learn more options than can be discussed effectively in a lesson covering differentiation as a concept. "Teach as you preach" should be the motto.

Later on in their career, teachers must keep learning and trying: practice makes perfect. This is done through in-service training, but also by observing colleagues at their own and other schools and sharing tips and experiences. This must of course be stimulated by school management, who should also facilitate differentiation in other ways, as described in section 4.4.

Finally, teachers must strive to learn from students. In addition to the necessary change in frame of mind detailed in section 4.4, teachers should also accept that they will not be able to answer every question their students ask. The response in these cases should be to encourage the student who is asking the question to research the answer and to help the student to do so.

4.6 Main Research Question: Given the Fact That Many Differentiation Options Are Available to Support Gifted Students, how Can Dutch Physics Teachers Be Empowered to Actually Implement These Differentiation Options?

Aggregating the conclusions from the previous sections in this chapter, the answer to the main research question is as follows: Dutch physics teachers can be empowered to implement differentiation into their teaching practice by increasing their teacher efficacy, as well as by adopting a new frame of mind. This frame of mind involves the following aspects:

- Teachers should listen to students and their needs, incorporate these needs in differentiated learning activities.
- Teachers should break through the idea that the secondary school curriculum is too rigid. Even within the tight schedule, room for differentiation can be found.
- Teachers should keep learning. Learn by doing and trying, learn from colleagues and teachers at other schools, and don’t be afraid to learn from students as well.

Two factors that are needed to help foster this mindset and the teacher efficacy, are a supportive school board and school management as well as a teacher training program in which differentiation is fully integrated.

Chapter 5: Discussion

5.1 Limitations

This study has four main limitations. The first limitation concerns the data gathered from teacher trainers. To explain this, some knowledge of the Dutch teacher training system is needed. In the Netherlands, there are two types of teacher qualifications, partial and full teaching degrees tracks (Wet op het voortgezet onderwijs, 1963-2020). The partial (*tweedegraads*) degree allows a teacher to teach students in the first three or four years of secondary school. Teachers who want to teach students in the last two or three years of secondary school need a full (*eerstegraads*) degree. These degrees can each be acquired in two ways. A partial teaching degree can be acquired through a four-year Bachelor's program at a university of applied sciences (*hoger beroepsonderwijs*) or through a Minor as part of a Bachelor's program at a university. The full degree can be gotten through a Master's program at either a university or a university of applied sciences. This means that there are four different types of institutions at which secondary school teachers are trained. For the sake of brevity and ease of comparison, only teacher trainers from university-level full teaching degree programs were interviewed for this study.

The second main limitation of this study concerns its generalizability. While this study is not quite a selection of case studies, its sample size is much too small to be representative of the entire Dutch secondary school system. Furthermore, the five teachers that were interviewed have quite different backgrounds and amounts of experience, which has not been taken into account in the present study. The question can be raised whether the findings from these five very different teachers are generalizable to the broader field of education.

Thirdly, all the data presented in Chapter 3 was gathered from interviews, and is therefore self-reported. No other forms of data were gathered, so triangulation in this way is not possible.

Fourthly and finally, a direct student perspective is absent from this research. This perspective was included indirectly through one of the interviewed coaches.

5.2 Implications for Future Research

For each of the limitations specified in the previous section, the researcher would like to suggest a study that could fill that gap.

The first limitation, that of the small selection of teacher training perspectives, could be solved by a review of the curricula of all Dutch teacher training programs, both partial and full degrees and both universities and universities of applied science.

The second limitation, that of generalizability, can be solved with a quantitative follow-up study. This study should be a survey study conducted among teachers across the Netherlands, with questions concerning teachers' opinion on differentiated instruction, their experience with differentiation during teacher training, the amount of support they get from their school board and management and to what extent they practice peer learning. This survey should also look for trends based on the background, age and amount of experience of teachers, as the present study did not take these factors into account.

The third limitation concerns the self-reported nature of the data presented in this study. The present study could be augmented by an observation study in which teachers' implementation of differentiation is tracked.

The fourth limitation is that of the lacking student perspective. An interesting study that could research this perspective is one where students are interviewed to find out whether the findings of Kanevsky (2011), Tomlinson et al. (2003) and others about what gifted and motivated students want and need do in fact hold for Dutch secondary school students.

5.3 Implications for the Field

Based on the results and conclusions presented in this study, some suggestions are offered to each of the groups of people interviewed. The researcher's advice is the following:

Teacher trainers: teach as you preach! This can be done by differentiating teaching methodology courses. If that is impossible due to small group size, each lecture could be used to

spotlight one differentiated learning activity, or a group of learning activities. In this way, starting teachers will naturally build up a repertoire of options they can use in their internships and in their later jobs.

Teachers: learn from your peers! Visit colleagues' classrooms and share ideas.

Coaches: work with teacher trainers! Help them ensure new teachers already know the basics when they start. This doesn't mean that coaches should dictate teacher training curricula, but if teacher trainers attend in-service training on differentiation, they might be more inspired and able to follow the advice given to them above.

A fourth piece of advice is for school boards and school management: support your teaching staff! Listen to them, give them what they need if possible, and work with them to create a solution if not. Facilitate the exchange of knowledge within your school and between your school and others.

If these pieces of advice are taken to heart, the daydreaming gifted child with whom this thesis started, will hopefully no longer be able to daydream: their lessons will be too engaging to get distracted.

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Appendix A – An example of Whole Task First

Table A1

An example of using the Whole Task First principle

Physics: Reasoning and calculating with the law of conservation of energy
Before
Most coursebooks start with the concepts of work, kinetic energy, gravitational potential energy and the potential energy of a spring, after which they introduce the law of conservation of energy. The type of task presented here comes at the end of the chapter. Scaling laws play no role at all in this regular ordering of the chapter on energy. Now that there is a national curriculum domain "Laws of nature and Models", it can be fitting to involve scaling laws. In a regular lesson, before flipping and condensing, this would be mentioned at the end, as a bonus.
After flipping and condensing
Whole task The teacher introduces the chapter with an instruction like the following: "Those who would like to tackle the entire problem themselves will work, in groups, with a worksheet to solve the problem I will introduce in a bit, this is the independent track. For all students this problem will be the perspective: in a few weeks, you will be able to solve the problem. But if you prefer to solve it in steps according to the coursebook, and want to try this big problem later on, that's an option too. Then you're in the guided track, which is also good. The students in the independent track will follow a separate program for four lessons, after that they'll join the rest of the class for the last six lessons. I guarantee that everyone will have been given all the necessary content for the test after this." "An ocean tugboat uses a cable that is about a kilometer long to move a drilling platform across the ocean. That's inconvenient because of the weight and price of the cable. Additionally, other ocean traffic must be redirected around the tugboat, the cable, and the platform, even though the cable is about 40 meters under the sea surface for most of its length. Even so, it is apparently necessary to have a cable that long. The task is: give a reasoning for why these cables are so long. Take into account what happens if the tugboat and the platform get too far apart and what happens when they get too close to each other." Students in the independent track get feedback on the worksheet they hand in at the end of the lesson, after which they get a follow-up task. Students in the guided track will follow a "regular" program in which the concepts of work and the types of energy are introduced. *Personalized assistance* The students in the independent track get feedback on their first worksheet, which will at least contain the following remark: "In the rest of your solution, you should at minimum use the following concepts: kinetic energy, gravitational energy, spring energy and conservation of energy." Later on, they will be asked to explain what happens if the drilling platform, which is being pushed away from the tugboat by a wave, gets double the velocity. What are the consequences of this for the needed length of the cable?

Note. Freely translated from Janssen et al., 2016, p. 269.

Appendix B – Interview Schemes

Teacher trainers

What has your own experience with differentiation been?

What is the best or most interesting example of differentiation you have done, experienced or heard of in your entire career?

How is the topic of differentiation explicitly covered in the mandatory teacher training curriculum?

How is this tested?

Is there any difference between the Minor program, the Master's program and – if applicable – the two-year Master's program?

Is differentiation also covered in elective courses? If so, how?

Are you content with the way in which differentiation is integrated into the curriculum at your institution? What could be improved and why?

To what extent is the education in your teacher training program differentiated?

Do you get any feedback from alumni on the way differentiation is taught in relation to their teaching practice? If so, what is the feedback?

Coaches – In-service training

What has your own experience with differentiation been?

What is the best or most interesting example of differentiation you have done, experienced or heard of in your entire career?

To what extent is classroom differentiation important, in your opinion? How does this relate to other forms of differentiation?

What are necessary conditions that make classroom differentiation possible?

Do you notice any difference between science subjects, social science subjects and humanities subjects when it comes to classroom differentiation?

What is the main focus of the trainings you give?

What are the main obstacles to effective classroom differentiation that you notice? In other words: what necessary conditions are missing the most often?

Are you content with the way in which differentiation is handled during teacher training? Why?

To what extent are teachers able to put into practice what they learned during teacher training?

Coaches – student coaches

What has your own experience with differentiation been?

What is the best or most interesting example of differentiation you have done, experienced or heard of in your entire career?

To what extent is classroom differentiation important, in your opinion? How does this relate to other forms of differentiation?

What is your impression of the way in which teachers from your network and the teachers of students you coach handle talented students?

To what extent do you collaborate with the teachers of students you coach?

Can you give an example of a collaboration or other result of your coaching that was effective? And one that did not turn out very well?

What kind of advice would you give to teachers who want to responsibly handle and care for talented kids in class?

What do talented students need from their teachers?

Physics teachers

What has your own experience with differentiation been?

What is the best or most interesting example of differentiation you have done, experienced or heard of in your entire career?

Do you apply differentiation in your own teaching practice? In which way(s) and why?

If no:

To what extent was classroom differentiation covered during your teacher training? How useful has that been in practice?

To what extent did you come into contact with differentiation after your teacher training, e.g. through in-service training?

Why do you choose not to differentiate your instruction?

(After this: keep asking about reasons, obstacles, what might make them change praxis)

If yes:

To what extent classroom was differentiation covered during your teacher training? How useful has that been in practice?

Why do you differentiate your instruction?

To what extent have you acquired skills and knowledge pertaining to differentiation after your teacher training?

To what extent do you encounter obstacles or pitfalls that make implementing classroom differentiation harder?

How are you circumventing or removing these obstacles and pitfalls?

Appendix C – Detailed List of Examples of Differentiated Instruction

All the examples of classroom differentiation that were mentioned during the interviews are below, labeled with which aspect of education listed in Table 1 is being differentiated: task level (Lv), tempo (T), process (Pc), product (Pd) or learning style (Ls). An additional label indicates which groups of interviewees mentioned the example how many times.

- Making instruction optional
    - Lv, T – teachers 4
- Use different levels of exercises/learning trajectories/practicals
    - Lv, sometimes Ls, Pc, or Pd– teachers 4
- The BRE-model: Basic content – repeated content – enrichment content (*BHV-model: Basisstof-herhaalstof-verrijkingsstof*)
    - Lv, T, Pc – teacher trainers 1, teachers 3 (2 implicit)
- Using Whole Task First (*Hele taak eerst* (Janssen, 2016)) as a skeleton for lesson design
    - All aspects are all possible to apply here – teacher trainers 3
- Group work (Expert groups, presentation groups, et cetera)
    - Pc, sometimes Lv, Pd, or Ls – teacher trainers 1, teachers 2
- Providing/supporting more than 1 learning style when preparing for tests
    - Ls, Lv, Pc – teacher trainers 1, teachers 1
- Peer-instruction, students explain subject matter to each other
    - Lv, Pc – teachers 1

Four examples of differentiation on a scale larger than the (regular) classroom were mentioned as well. These are listed below, labeled with by whom and how many times they were put forward.

- Enrichment programs like UTalent – coaches 1
- Finishing a subject a year earlier or at a different level – coaches 1, teachers 1
- Optional extra lessons, “choice hours” where students choose which subject to attend – teachers 1