The Effects of Differentiated Instruction on the Interests of Talented Students in High School Science Classes

Matthew Decovsky

December 10th 2012

Utrecht University

The Effects of Differentiated Instruction on the Interests of Talented Students in High School Science Classes

Author: Matthew Decovsky
Email: m.decovsky@students.uu.nl
University: Utrecht University
Faculty: Graduate School of Natural Sciences
Degree Program: MSc Science Education and Communication
UU student number: 3741931
Research Supervisor: Ton van der Valk, Freudenthal Instituut/JCU (a.e.vandervalk@uu.nl)
Second Examiner: Arthur Bakker (a.bakker4@uu.nl)
30 ECTS

Abstract:
In many mixed ability high school classrooms today, teachers are forced to teach to the middle. This method may leave slower students behind, and alternatively, slow down the smarter, more talented students. Differentiation is a form of instruction aimed at addressing an individual's readiness level, interests, and abilities. According to pertinent literature, talented students require more abstract, complex, difficult and deep assignments (VanTassel-Baska, 2002; Berger, 1991) while students at all levels benefit from choices in their learning environment (Nunley, 2003; Tomlinson, 2001). Little empirical research has been done as to what it is about differentiation that actually interests a talented student. This research focused on the particular aspects of differentiated activities that had the most impact on student interest for gifted and talented high school students.

Four main elements inherent in differentiated assignments were chosen (*difficulty*, *depth*, *choice*, and *ownership*), and students from three schools in The Netherlands were interviewed to determine to what degree each element affected their interest in the learning material. In addition the research was based on the three curricular levels of Jan van den Akker (1998), which include the curriculum as perceived by the material designer, the teacher and the student. It was found that the interest of students was highly dependent on what each activity afforded to them, yet all students had a desire for more complex and deeper problems, and all showed a strong interest to learn more about topic at hand. Within each sample, it was found that the data matched quite well on each level. The elements students found most influential with respect to interest were usually the same elements that teachers felt would affect interest, and were the elements most prevalent in the activity.

Keywords: differentiation, interest, curricular levels, Netherlands

Table of Contents

Introduction

In traditional classrooms today it is almost impossible to teach a subject at every student's personal level. Every student is different, and what works for or interests one student may not interest or work as effectively for another. Teachers commonly "teach to the middle" where the average lesson content is at the ability level for average students. This is especially true in classrooms with mixed ability students. This not only affects the slower students in the class, but also drags down the more talented students, who get bored with material they may have already mastered. The result is that talented students in mixed ability classrooms are often working at a lower level, which can lead to boredom, lack of motivation and sometimes poorer results (Subban, 2006; Tomlinson, 1997)

As a partial solution, differentiation is a form of teaching that caters to the needs of both the individual students and the teachers. It is meant to be a qualitative, proactive, multiple approach system to create lessons and activities that accommodate student differences in interest, readiness, and intelligence. It also helps them to cope with challenging topics in ways that are comfortable to their ability level (Beecher & Sweeny, 2008; Berger, 1991; Hall T. , 2002; Evans & Waring, 2011). There are many forms of differentiated instruction but what they all have in common is that they are implemented as some fraction of the whole curriculum and allow students to choose their own path based on ability, interest, and readiness. This allows the teacher to scaffold the learning more effectively and allows the students to explore a topic they are interested or motivated by, at their own pace and ability level (Subban, 2006; Nunley, 2003).

This research seeks to add to the empirical research base by researching talented student interest using differentiated instructional materials, including materials from the website www.betadifferentiatie.nl. This website is an online resource aimed at providing differentiated lesson materials (in Dutch) in the fields of mathematics, physics, chemistry, and biology. The materials vary in level and are designed to be used as supplements to regular instruction. Each level is aimed at either reinforcing previous concepts (*herhalend*), enriching the material by exploring concepts outside the domain of the regular curriculum (*verrijkend*) or diving deeper into the real life applications of the concepts outside of the regular curriculum (*verdiepend*) (van Dijk, van Velden, Meijer, & van der Valk, 2010). These materials, among others, will be used as the intervention method for the research and will be used in the setting of mixed ability classrooms in The Netherlands. The results from this research will not only add to the research base, but also give insight to future material design.

In order to research the interests of gifted and talented (G&T) students it is necessary to delve into the needs of gifted learners and determine how differentiated instruction can suit those needs. Interest was chosen as the main variable to focus on because interest can improve motivation and learning results. With proper motivation piqued by subject interest, students of all ability levels are shown to improve in a subject area (Dohn, 2010; Hulleman & Harackiewicz, 2009; Schiefele, 1991). Moreover, Dohn (2010) shows that situational interest – interest piqued as a result of a lesson or activity – can foster a long term personal interest in the subject. While there is a plethora of literature which addresses and supports differentiation, there is not enough research which addresses the effects of differentiation on gifted and talented high school science students.

Theoretical Framework

Since the research revolves around interest, it is necessary to define "interest". From a cognitive psychology standpoint, "interest emerges from an individual's interaction with his or her environment. It represents a specific relationship between the developing person and some content or topic of his or her life space." (Krapp, 1999, p. 24) Furthermore, Krapp (1999) states that interest is comprised of both cognitive and affective components, and is a synthesis of the two domains. Schiefele (1991) links interest with intrinsic motivation, stating that interest is a layman's term for intrinsic motivation, but the latter does not encompass all of the important components of interest. Deci and Ryan (cited in Schiefele, 1991) refer to interest as "an important directive role in intrinsically motivated behavior in that people naturally approach activities that interest them" (pp. 300).

Interest in a learning environment can be divided further into categories which include individual interest, situational interest, and the "interestingness" of the learning context. Individual interest represents a dispositional characteristic of the person, and is linked to situational interest, which is a temporary psychological state of the person, piqued by an activity or lesson. Interestingness refers to characteristics of the learning context, which is linked to situational interest (Krapp, 1999). While "interest" is a complex concept, it is clear that the interestingness of a learning context affects situational interest which can be molded into a long term individual interest (Dohn, 2010). The importance of student interest is paramount as it promotes meaningful learning (Schiefele, 1991), provides motivation for further learning, and improves learning results (Hulleman & Harackiewicz, 2009; Schiefele, 1991).

With interest defined as the main variable to research, it is now necessary to look at the theoretical background of differentiation and a proper gifted curriculum. Numerous studies have been done about what is needed for a proper gifted curriculum, and the common theme in all of them is a need for complex, abstract assignments that not only stimulate the learner's interest in the subject, but also provide a proper difficulty level, without repeating the same types of problems (Schiever & Maker, 2002). According to Schiever and Maker, gifted students are those "who can solve the most complex problems in the most efficient, effective, ethical, elegant , or economical ways. […] The key element is enjoyment of challenges and complexity." (2002, pp. 163) VanTassel-Baska (2002) also advocates activities that are more focused on depth as opposed to breadth and on concepts over facts. Additionally, the key elements should include real world scenarios and applications of ideas, which are more abstract and complex than the normal curriculum offers.

There are multiple didactic strategies that fit the above suggestions for facilitating students classified as gifted or talented. These include, but are not limited to: acceleration, enrichment, and differentiated instruction (Schiever & Maker, 2002). Whereas enrichment takes place outside of the normal classroom, acceleration takes place in a classroom at a faster pace (but the material is the same for all students). Differentiated instruction allows gifted students the opportunity to broaden their learning horizons with enriching, deeper assignments that cater to their interests, while working *within* their normal classroom environments. Tomlinson (1997) gives an overview of important qualities in gifted education. These include a curriculum that is suited to student needs in terms of complexity and pace, and one that is structured enough to support students without being overly constricting. The content and processes should be more complex and open-ended than their typical counterparts, and the assignments should be more multifaceted, more abstract, and require more skills in order to complete them. All of these qualities are found in differentiated materials, making differentiated instruction a feasible and suitable method for delivering quality instruction to talented students.

There are many forms of differentiation, but the end result is the same - delivering curriculum to the student at his or her level. Differentiation is most often broken down into three areas – differentiation of process, content and product (Tomlinson, 2001). Additionally, Berger (1991) states that in addition to content, process and product differentiation, modifying the learning environment "encourages them [gifted students] to question, exercise independence, and use their creativity." (p. 3)

With the focus on differentiated instruction as a viable means to deliver higher level instruction to talented students, it is necessary to focus on the prior research in the realm of the natural sciences that supports differentiated instruction for gifted students (Physics, Chemistry, Math, Biology, etc.). Numerous articles were found that *theoretically* supported differentiation as an excellent curriculum delivery method for gifted and talented students. Differentiated instruction is suitable for gifted and talented students because it allows for a broadened approach to problem solving, and higher levels of complexity and abstractness can be achieved through the choices of the student. These are seen as positive qualities in gifted education (Schiever & Maker, 2002).

From an empirical research standpoint, it was found that students (of all abilities) who were allowed to choose topics which suited their interests showed increased performance on those subjects, as well as more positive attitudes towards the overall topic (Reis & Fogarty, 2006; VanTassel-Baska, 2002). Chamberlin (2011) compiled data from prospective elementary education teachers and their feelings towards differentiation from practice lessons. Her research concluded that teachers felt that students were more involved and the lessons were tailored to individual students' needs when they were differentiated for content and process. Furthermore, they felt that the inclusion of a choice in subject matter increased the overall interest and motivation of the students. Although her research focuses on elementary education of typical students, it is interesting to note that the students replied that their interest in the subject matter was increased because they felt that were given a choice to direct their own learning. Logan states that, "When a student's interest is tapped, learning is likely to be more rewarding and the student may become an autonomous learner." (2011, p. 11) Saldanha's (2007) research found that the attitudes towards science of high school students in chemistry and environmental science classes were positively affected by differentiated content and product instruction as compared to traditional teaching. She also concluded that their achievements in these courses were slightly improved with the differentiated instruction. Nunley summarizes the importance of student interest, stating: "Any type of student centered classroom increases learning because students perceive they have made their own decision to do an assignment and they take ownership in the work." (2003, p. 33) While these articles support the theory of differentiation and link it to an increase in interest in general education settings, there was little found on the effects of differentiated instruction on the interests of G&T students in the natural science fields.

From a pedagogical standpoint the aforementioned research has shown that differentiated instruction is in fact a very viable method for gifted students. Additionally, from the aforementioned research, differentiated instruction leads to increased interest and motivation in *typical* students in a general education environment across many subjects – but can this be extrapolated to gifted students? Furthermore, how are the interests of talented students affected by differentiated instruction in a mixed ability high school classroom? There is not enough empirical research on the effects of differentiation with respect to interest in general (Kondor, 2007; VanTassel-Baska, 2012; Logan, 2011), let alone on the focused topic of the interests of gifted and talented students in the science fields.

Research Aim and Research Questions

While the materials from www.betadifferentie.nl (BD materials) have been used and tested at the Junior College Utrecht (JCU), little has been done in the way of research with other schools that use the materials (van der Valk, Grunefeld, & Pilot, 2010). In a broad sense, it is important to know if differentiated instruction in a high school science classroom truly results in increased student interest, which can lead to increased motivation and therefore better performance in a subject area (Nunley, 2003; Tomlinson, 1997; Reis & Fogarty, 2006; Subban, 2006). In the theoretical background it was determined that differentiation is a valid, useful, and efficient (for both students and teachers) curriculum delivery method for high school science classrooms.

In order to solidify the aforementioned theories regarding the use of differentiation as a valid intervention to pique the interests of gifted student and to extend the previous research involving the interests of G&T students using differentiated materials, this research project aims to use differentiated materials (similar to those on the website) to see how G&T student interest is affected by differentiated instruction. The research will focus on gifted and talented students (as indicated by their teachers) to determine if differentiation is a good way to keep talented students interested in the subject area and performing at a high level while working in a mixed ability classroom. To more effectively determine where the interest stems from I want to determine *what aspects* of the differentiated materials interest them. The research question is: *Which elements of a differentiated activity add to the students' interest in that topic and to what degree?*

The elements include *Choice* (Chamberlin, 2011; Reis & Fogarty, 2006; Tomlinson, 1997), *Ownership* (Nunley, 2003), *Difficulty* , and *Depth* (Schiever & Maker, 2002; Tomlinson, 1997). These elements were chosen because they were identified as variables that can affect interest from the didactic theory behind differentiation. For this research the elements are defined as follows:

1. Choice
    a. Choice of learning material - The fact that students to some degree get to choose *what* they learn, or which assignments or problems they wish to complete
    b. Choice of learning path – the fact that students get to choose *how* they engage in the learning process
2. Ownership
    a. The fact that the end product is original
    b. The fact that the thought process is original
3. Difficulty – the fact that the material is difficult and complex enough to promote meaningful/interesting learning
4. Depth– the fact that the material requires new or extended concepts or skills and is interdisciplinary

Additionally, I will look at the curriculum from three levels as outlined by van den Akker (1998, pp. 421-422), which include the formal curriculum ("the vision elaborated by a curriculum document"), the perceived curriculum ("the curriculum as perceived by its users (usually teachers)") and the attained curriculum. The attained curriculum can be broken down into the experiential curriculum ("learning experience as perceived by learners") and learned curriculum ("resulting learning outcomes of learners"). In order to see how the aforementioned elements compare at each level I propose three sub-questions. Sub-question 1 on the formal curriculum level: *Which of the elements are present in the chosen lesson materials and to what degree?* Sub-question 2 on the perceived curriculum level: *From the point of view of the teacher, which of the elements in the differentiated activity were influential to student interest and to what degree?* Sub-question 3 on the attained/experiential curriculum level: *i) from the point of view of the students, which elements of a differentiated activity were influential to their own interest and to what degree? ii) Which elements of a differentiated activity can be recognized by the researcher in the student products, and to what degree?*

The purpose is to see how a student's interest compares to the teacher's perception of their interest, and how these are provided for in the design and implementation of the activity. By comparing these three levels, a relationship can be seen between the built in aspects of the materials from a designer's perspective, how these are implemented and received in the classroom from a teacher's perspective, and finally, how the interests of students are affected.

Methodology

In order to answer these questions three data sources were used:

1. The materials used (formal curriculum)
2. The teacher interpretation of the materials and student interest (perceived curriculum by teacher)
3. The talented students' self-reported interest in the topic
    a. Perceived curriculum by students (interviews)
    b. Attained curriculum by students (student end products)

The following steps were necessary to answer the research questions:
Step 1: Materials – The first step was to analyze the materials and compare their design with guidelines stated in the literature. The goal was to see which aspects (*Choice*, *Depth*, *Ownership*, *and Difficulty*) were present.
Step 2: Teacher Interpretation of Materials and Student Interest – Through interviews, it was learned how the teachers viewed the materials and how they felt the interests of the students were affected by the use of the materials with respect to the elements of choice, depth, ownership, and difficulty.
Step 3a: Student Interest – Through the use of interviews, students' interest was determined as affected by different aspects of the materials/learning environment themselves and also by the topic the materials cover as a whole.
Step 3b: The attained curriculum (final products) of the students (when available) was compared to the formal curriculum and perceived curriculum.

To complete Step 1 a materials analysis was completed. The purpose of the analysis of the differentiated materials was not only to gain insight into the creation and design of differentiated activities, but also to support the materials as valid instruments in the research intervention and to be able to compare the materials on the three curricular levels. The presence of the initial elements in the materials was also studied to see if and how the designers included them in the activities. To analyze the materials a rubric was made using criteria outlined in the literature. A more thorough explanation of the rubric can be found in the data analysis section.

In order to get an idea of the teachers' interpretations of the materials (Step 2), teachers were interviewed about the materials and how they thought the activities and the different aspects of the activities affected student interest. These interviews were used to determine how the teachers perceived student interest with respect to the differentiated activities, and the interviews were compared with the student responses. A coding scheme was used to code the teacher interviews and determine which elements the teachers felt affected the student interest the most.

Interviews were used in order to gain information about the teaching/learning situation (Step 3a). Where possible, additional data sources such as student feedback or student materials were used to triangulate the data and compare them to the interview results. Information from these interviews was mainly used to determine which aspects of the differentiated activities make them the most interested in the topic and to what degree the aforementioned elements play a role. For step 3b, the students' final products were compiled and analyzed to see how the elements were present in the products and if the final reports/products were in line with the goals of the formal curriculum and teachers perceived curriculum.

To answer the final sub-question (comparison of the different curricular levels), the analysis of the materials was compared with the responses from the teacher and student interviews to see how the interests of the students compared to their teacher's perception of their interests. The designer's perception of how the materials will interest the students was also compared.

As a general note, from the first interviews conducted, the additional elements of *motivation*, *recognition,* and *relevance* came up. Motivation is usually linked with interest (Schiefele, 1991), while recognition and relevance might affect the former and are elements that may have an effect on the interestingness of the learning environment. These three elements were added to the coding scheme under the theme of student experience.

Sample

This research was a multiple case study with three samples of students from three different learning environments/schools in the Netherlands. In total, eleven students and three teachers were interviewed from the three schools. Each interview subject was given a code based on the following scheme: school letter + S/T + number, where S/T denotes a teacher or a student.
The three schools (with preceding code letters) were:

A) Het Nieuwe Lyceum, Bilthoven (4 students)
B) Junior College Utrecht (JCU), Utrecht (4 students)
C) Revius Lyceum, Doorn (3 students)

There are numerous tests and methods to determine giftedness (see Davis, 2002) and due to the small sample size for this research, the decision was left up to the teachers to decide who they felt were the most talented students in a class. In the case of School B (JCU), the students had already undergone a rigorous entrance exam, administered by the University of Utrecht. The selection process for each case is described in its respective section below.

School A

The first school (A) is a Dutch public high school, offering HAVO, athenaeum, and gymnasium. It is located near Utrecht, with 100 personnel and 900 students from Gymnasium 1 to VWO 6. The sample for this school was four students (coded AS1-AS4) in a Gymnasium 2 (grade 8) physics class. They were all 13-14 years old, and the group consisted of three males and one female (AS3). The teacher had a PhD in plasma physics, an MSc in science education and one year of teaching experience. The differentiated assignment was designed by the teacher himself, and he selected eleven students from three classes to complete the assignment. While this class was still at the gymnasium level, the teacher noticed large differences between the skills of the most talented students and the rest of the class. The selection process was multifaceted, as students needed to i) have higher than an 8 average in the course, ii) score higher than a 6 on a pretest covering the brand new material, and iii) volunteer to participate. The differentiated assignment was a replacement for the normal experiment, and was graded. The content of the differentiated practicum was digital circuits and system boards. The activity was performed over the course of 9 lessons and students needed to finish their regular class work if they wanted to work outside of the given time slot.

School B

The second school (B) is the Junior College in Utrecht, a separate school program for talented students from the mid-Netherlands regions who have shown a talent for the natural sciences. Courses in Biology, Mathematics, Physics, and Chemistry are offered twice per week at the JCU, and replace the normal school courses in these subjects. The selection process for students is rigorous, and only the best and brightest students are chosen to attend. JCU offers courses for grades 5 and 6 VWO, and there is a lot of work done with differentiation in this school.

The students interviewed were all chosen based on a willingness to participate and availability at the time of interviewing. The students (BS1-BS4) were all male VWO 5 students (ages 16-17) who completed two different assignments. BS1 and BS2 completed a biology assignment involving medical drug research (each student researched a different drug); BS3 and BS4 completed a mathematics assignment. Each assignment was at the end of a corresponding module and the students got to choose which differentiated activity to complete. The activity was completed over a five week period. Students had one lesson hour (75 minutes) per week for four weeks to complete the assignment, and each gave a presentation during the fifth week. The assignments were not graded, but a teacher checked participation to keep students on track. The teacher who was interviewed for this school was a physics teacher who had been with JCU for five years, and all of the students had participated in differentiated activities in his physics class. He did not, however, preside over the specific activities that the interviewed students completed.

School C

The third school (C) is a Dutch public high school which offers MAVO+, HAVO and VWO to 1,488 students. The selected students (CS1-CS3) were part of a beta-excellence pilot program and they completed two differentiated activities over the course of the year. The first activity involved molecules and this was the first time that module was tested at the school. The second activity was about viscosity and was completed by all three students. All of the activities were completed outside of classroom, and were similar to those found on www.betadifferentiatie.nl.
The three students were all in 4 VWO (14-15 years old) and the group consisted of two males and one female (CS2). . The selection process of the interviewed students was done by the school since they needed high grades in all subject areas and proven talent in the natural

sciences. In addition, they needed to be acceptable candidates for the JCU. CS1 and CS3 were chosen for the JCU for the following year, while CS2 did not make the cut.

The interviews focused mainly on the physics activity about viscosity which was completed over the course of 8 weeks. This activity was completed shortly before the interview; however, the students also mentioned the pilot activity “Molecules in Motion” that they had completed 9 months earlier. The teacher interviewed was the main science teacher for the school with over 30 years of teaching experience. He helped create the differentiated activity and was in charge of implementing the beta-excellence program at this school. While he was not the teacher involved in the activity on viscosity, he was closely involved with process.

Data Collection

Because of the multi-layered nature of the data sources, multiple methods were used to collect the data.

Interviews

All interviews were semi-structured and followed the same interview scheme: questions for the students focused on how their interests were affected, while questions for the teachers were focused on *how* they thought the students’ interests were affected. All of the student interviews were group interviews with two students per interview, except for the case of School C, which was a group interview with all three students.

The interviews were recorded, and interviews conducted in Dutch were transcribed in Dutch and then translated into English. The translations/transcriptions were checked with colleagues to ensure accuracy.

The interview scheme for the teachers and the students was almost the same, the only difference lying in the wording of the questions. For example, students were asked how a certain aspect or element affected their interest, while the teachers were asked how *they thought* student interest was affected by the aspects/elements of the activities and the teaching/learning process.

Differentiated Materials and Student Products

The differentiated assignments and student final products were also analyzed. All assignments were received from the teachers and end products collected from the students. In the case of School C, the end products were not yet finished, and thus have not been received by the researcher.

Additional Data Sources

For School A, Het Nieuwe Lyceum, the teacher gave surveys to the students to get their feedback on the assignment. In addition he had them write up a short feedback paragraph in their final product, with their opinions of the differentiated activity and the learning environment. These surveys and feedback forms will be used as additional data sources to triangulate the student data from School A.

Data Analysis

Interview Analysis

To analyze the interview data, interviews were first transcribed and all interviews conducted in Dutch were transcribed and then translated. Unclear audio segments or uncertain translations were double checked with peers to improve accuracy and clarity. All interviews were member checked, except for the interviews from School B, since email addresses were not collected.

The transcribed interviews were then coded using a coding scheme which can be found in Appendix B. Both student and teacher interviews were coded using the same scheme. To unitize the transcripts, each sentence was taken as one unit of analysis, and therefore each pertinent sentence was given one code. Sentences were created by the researcher at his discretion during the interview transcription process.

The labeling scheme was broken down into the following format:

- Key Theme
    - Sub Theme
        - Label
            - Code/Factor

Codes were used to analyze the responses even further, and the full list of codes/factors can be found in Appendix B. Codes were determined not only from relevant literature in the theoretical framework, but also from responses from students. The most common and important responses were pulled from the interview analysis and were used to make the interview coding scheme.

For example, in coding for the differentiated activity, a student response might include the fact that he liked the difficulty aspect because it provided a challenge. Therefore the code or factor for the difficulty aspect/element in the theme of the differentiated activity was 'challenge'. A factor that affected choice might be 'choice of approach' or 'choice of problems'.

For each school the, code totals for teachers and students were tabulated side-by-side and the frequency of responses was compared. For both sets of interviews, across all samples, the most common factors for each code/label were determined and compared side by side. Additionally, the most common sub-theme was determined, to rank the sub-themes on how influential they were to the student interest.

Using this side by side comparison, the responses of the students and teachers were compared to determine if there was a match between what was most influential to the student interest according to the students and the teachers.

Materials Analysis

In order to compare the data on van den Akker's three levels, the materials were analyzed to see how they provide for the key elements outlined in the research question. In order to analyze them a rubric was made to score the materials and determine to what degree they provided for each element.

The rubric (Appendix C) grades the presence four elements (*difficulty*, *choice*, *ownership*, *depth*) and each activity was given a score from 1 to 5. For the element of *choice* the rubric is used to determine how much choice the students were afforded in the assignment with respect to learning material, choice of approach, solutions, problems, etc. For *ownership* the rubric grades each assignment by how much the students were able to use their own process or to create their own product. To score *depth* and *difficulty*, four criteria were made for each element. The rubric score was based on how many of the criteria the activity contained. The chosen criteria were determined using pertinent literature. For the element of *difficulty* the criteria included: abstraction/complexity, quantify/measure, apply in a context, more skills/multifaceted approach needed. For the element of *depth* the criteria included: new concepts, extended concepts, new skills needed, interdisciplinary nature.

Results

The main research question was to determine *which elements of a differentiated activity add to the students' interest in that topic and to what degree?* To answer the main question, the sub-questions were:
Sub-question 1 on the formal curriculum level: *Which of the elements are present in the chosen lesson materials and to what degree?*
Sub-question 2 on the perceived curriculum level: *From the point of view of the teacher, which of the elements in the differentiated activity were influential to student interest and to what degree?*
Sub-question 3 on the attained/experiential curriculum level: *i) from the point of view of the students, which elements of a differentiated activity were influential to their own interest and to what degree? ii) Which elements of a differentiated activity can be recognized by the researcher in the student products, and to what degree?*

The four main elements included *Choice*, *Difficulty*, *Ownership* and *Depth*. In addition, the research also looked at student experience, which included the motivating and demotivating aspects of the activities, as well as the aspects of *Motivation*, *Relevance* and *Recognition*.

Using the interview data and the data collected from the activity and student product analysis, the data were compared on the three curricular levels of van den Akker. This was to see how the main elements of interest stated above were present in each level and to what degree they influenced student interest.

School A – Het Nieuwe Lyceum

Summary

For School A it was found that the *difficulty* of the activity was the most influential element piquing student interest, followed by *choice*, *depth,* and *ownership.* Concerning the elements present in the differentiated materials (sub-question 1), the element of *depth* was the most influential in the activity; it focused on an increased depth and allowed students to dive deeper into the subject matter. *Choice* was next, followed by *difficulty* and *ownership.* Concerning the teacher's perception of the students' interests (sub-question 2), the teacher found the element of depth to be the most influential on their interests. He felt that this was due to the multi-disciplinary aspects of the assignment. All students agreed there was more *depth* and *difficulty* in the activity compared to a normal lesson. The teacher agreed and also felt there was more *choice* involved. Finally, to compare the data on all three curricular levels, the formal and perceived curriculum match perfectly with respect to the ranking of most influential elements, while the students views match only with respect to *choice* and *ownership* being ranked second and fourth most influential, respectively.

Materials Analysis

The activity for School A was designed by the teacher (AT1) and given to twelve participating students from two gymnasium 2 classes. The activity - titled "Systeembord en Digitale Schakelingen [System Board and Digital Circuits]" – required the students to complete problems using a system board and different circuits and switches. They explored each function and constructed the different possible circuits, which were to be used in later problems.

The students then had to complete more complex problems, which increased in difficulty as the students moved through the assignment. The students were asked to try to complete all of the problems, but for their final report the students needed to describe how each digital component on the system board worked, and each group needed to choose one solution to a complex problem to explain in detail.

The materials analysis rubric was used to score the activity and determine which elements were present in the activity. Table 1 below shows the scoring for this activity.

Table 1: Rubric scoring totals for the System Board activity

Element	Score (1-5)	Notes
Difficulty	3	2/4 criteria met: context, many skills needed
Choice -Approach -Learning Mat'l -Solutions -Problems	 5 1 3 5	
Ownership -Process -Product	 4 2	
Depth	5	4/4 criteria met

As seen in the table above, depth and the choice of approach and problems were the most influential and common elements provided by the activity. The activity also provided for ownership with respect to the process, and had a moderate degree of difficulty.

Interviews

Teacher Interview

From the interview of AT1 at School A, it was found that he felt that the normal lessons were too easy and boring for the selected students. His views of how the students perceive a normal lesson correspond almost exactly to how the students responded in their interviews.

Regarding the differentiated activity, he thought the most influential element was *depth* and the multi-disciplinary aspect therein. The fact that the activity focused not only on physics, but also on logic and mathematics made it a much deeper assignment for the students.

The teacher felt that *choice* was a big factor in the interests of students, and he felt the aspect of choice with respect to problems was the most influential characteristic of his activity. According to the teacher, the fact that the students had a choice was motivating, and increased their interest in the activity.

AT1	I think uh, if people have a choice, even if it's a choice between two things they don't like, it immediately increase the motivation because at least they have some influence on what they are doing, so I think, yea, I think it's crucial, I think choice is crucial, they have to be able to say "ok I want to do that and that", even if they don't like either.

The four elements were ranked from the teacher's perspective, and he found that *depth* was the most influential element of the activity that added to student interest. He found *choice* to be second most influential, with a choice of 'problems' as the most common response. Lastly, he found both *difficulty* and *ownership* to be the least influential in student interest.

In terms of student experience, the teacher AT1 felt that the students were highly intrinsically motivated by the challenge first and foremost, followed by a general interest in the topic. He also felt that they were extrinsically motivated by grades; he felt that most of them wanted to receive a high grade for this assignment.

The teacher also found that *recognition* was a major factor in the student experience, with the most influential factor being recognition from the teacher. He also felt that recognition was a positive element in the assignment, stating:

AT1	Right and also the fact that they feel, they feel noticed, I think that's pretty important too, **they know** that **you know,** that they're way beyond what we're doing now…

The students' most common response concerning recognition was the fact that they were a select group, and only a few of them were allowed to complete the assignment. A few mentioned that recognition was not a major motivator for them, but agreed that being in this select group of students felt nice.

The teacher felt that relevance did *not* play a major role regarding student interest.

Student Interviews

It was found that all of the students were interested in the topic before they began the activity, and the most common response (code) about the normal physics lessons was that were they too easy; the majority of the sampled students felt bored during normal lessons.

However, when asked if the differentiated activity changed their interest the students responded that they were still equally interested in the topic, confirming their prior interest.

Interviewer	Did this activity change your interest? Increased? Decreased?
AS3	Well, I **still** like it, but I know more about it

This concept of 'knowing more' was a common theme with this group; gaining 'more knowledge' was the most common response.

For the element of *difficulty* the students were almost unanimous that it was not a very difficult assignment, albeit more difficult than a normal lesson. Still, they liked that it was harder and a challenge for them, and were very positive about doing something that was more difficult and interesting compared to a normal lesson.

About the difficulty in general:

AS4	Yea I thought it was - in the beginning I thought it was not too easy, but later I understood it much easier
AS3	Yea, because there is also, at least I think that, because there is also real practical aspect, and that you have to do [the practical stuff] what you learn, I think that's, yea, then you actually understand it.

The third element was *ownership*, and all of the students found that this was not present in this activity. They felt that it was unoriginal, and it did not provide them with a sense of an original process or product.

AS1	Yea we had the feeling like we made it but it's not my invention, not like that. You always have [the feeling] like someone else did it too.

The last element was *depth*, and all students were unanimous and positive about the increased depth of the assignment, as compared to the depth of their normal Gymnasium 2 physics lesson. Furthermore, the *depth* played a large role in their interests, and the most common reason was that there was a 'real life' aspect to the activity.

From these four main elements, it was determined that the *difficulty* was the most influential element with regards to their interest. While they did find it easy (the most common response), they also found it more difficult than a normal lesson, and still a challenge to complete. The complete rankings from this group can be seen in Table 2.

The final theme of student experience was analyzed, with elements of *motivation*, *recognition* and *relevance*. For *motivation* the students were all equally intrinsically motivated by future goals, interest, and the challenge. The element of *recognition* was also a positive factor, as the students unanimously felt it was nice to be part of a select group that was chosen to complete the assignment. The students had mixed feelings about *relevance*, and this can be attributed to the personal interests of the students. Student AS1 and AS2 for example were very interested in electronics and planes, and therefore found personal relevance with this assignment, while AS3 and AS4 found it irrelevant, yet still interesting. The teacher only mentioned relevance once, and was talking about how the activity was probably relevant to AS1, who he knew loved electronics and planes. Despite a lack of relevance, all students said they enjoyed the assignment and would participate in a similar activity in the future if given the choice to do so.

Student Product Analysis

For the product analysis, two final reports from two groups of students were used. Only two interviewed students were part of these two reports; one group contained AS3 and the other

contained AS4. From the student reports it was found that all of the students completed the activity and chose a fairly difficult problem to fully work out and hand in, per the instructions of the activity. The group with AS3 chose a fairly difficult problem, while the group with AS4 chose a moderately difficult problem. Both problems had multiple solutions, so the students explained how they solved the problems using the system board and included diagrams of the solution.
The elements of choice, difficulty and depth are clearly seen in the student reports. They were able to choose which problems to complete, and they chose moderately to very difficult problems. Additionally, the material throughout the activity and their answers in the reports were deeper than what a normal assignment or lesson would require.

Additional Data Sources

In the case of School A, the teacher (who also designed the activity) gave feedback surveys to the students and asked them for their feedback in their final reports. Much of this data corresponds with the data collected from interviews. 66% of the students agreed that they had learned a lot from the practicum, and 80% said they enjoyed it very much and would participate again in something similar. The majority agreed that they were given a large amount of freedom during the practicum, both in *how* they were able to work, and in their choice of *which* problems to complete.

The students also provided feedback comments in their product reports, which match up well with their responses in the interviews. From the group with AS3:

> *"In general we thought the activity was very instructive, and fun. The independence gave you the freedom to work in your own way, while the working together also made it easy"*

AS4 also mentioned specifically how he was bored in a normal lesson and how this activity helped to change that feeling:

> *"I really liked participating in this activity, now I also wasn't bored during the lessons (because I got most of it already). This was really much different from the normal lesson, but really great."*

Comparison – School A

To answer the research sub question, all the data sources (materials analysis, teacher interviews, and student interviews/products) were compared on van den Akker's three curricular levels. An overall comparison of all three levels can be seen in Table 2.

Table 2: Overall Ranking Comparison for School A on van den Akker's three curricular levels

Rank	System Board Activity (formal curriculum)	Teacher (perceived curriculum)	Students (attained curriculum)
1	Depth	Depth (Multi-disciplinary)	Difficulty (Challenge/Hard)
2	Choice	Choice (Problems)	Choice (Problems) Depth (Real Life aspects)
3	Difficulty Ownership	Difficulty (Challenge/Hard)	-
4	-	Ownership (Process/Product)	Ownership (Unoriginal)

From a materials analysis standpoint, the elements of *depth*, *choice of approach*, and *choice of problems* were the most prevalent in the activity. The students found that both *choice* of problems and *depth* were the second most important element influencing their interest, while the teacher found that *depth* and *choice* were the most influential. Both teacher and students cited choice of problems as an influential factor. Students were able to choose to complete as many problems as they wanted, and most chose to complete all of them. From the student products, it was found that they followed the instructions and freedoms afforded by the activity and chose as many problems as they wanted, and solved more difficult and deeper problems for their final report. The teacher described how the process was important to the student's sense of ownership because they used the system board to create something which solved a problem. Conversely, the students agreed that building something was nice, and it added to a sense of accomplishment, but they were staunch in stating the fact that they didn't feel as if they had invented or created anything; they knew that these things had been made before, and any original process they came up with was not influential in their interest in the activity.

All in all, the data on levels one and two (formal and perceived) matched perfectly, while the perceived and experiential levels were off slightly, with only *choice* and *ownership* matching. Since the activity afforded choice and depth, and was created by the teacher, it is quite probable that the student and teacher responses were based on the fact that the activity provided for these elements more than the others. Additionally, the most common responses (codes) for both teacher and student matched for all elements except ownership; the teacher was well aware of *what* his students found interesting in the activities.

School B – Junior College Utrecht

Since the Junior College Utrecht (JCU) is not a normal school with mixed ability students, the comparisons to normal lessons were not necessarily directed at a normal school, nor were the students attending the same schools. Therefore, it should be known that any comparisons the students made to a normal school are not necessarily equally representative of the actual typical school situation.

Summary

For School B it was found that the *choice* of the activity was the most influential element piquing overall student interest, followed by *depth*, *difficulty,* and *ownership.* Concerning the elements present in the differentiated materials (sub-question 1), the element of *depth* was the most influential in the activity; it focused on an increased depth and allowed students to dive deeper into the subject matter. *Choice* was next, followed by *difficulty* and *ownership.* Concerning the teacher's perception of the students' interests (sub-question 2), the teacher found the element of *choice* to be the most influential on their interests, followed by *depth*, *difficulty*, and *ownership*. Of these four elements, the students felt that the difficulty was less than a normal lesson at the JCU, whereas the depth and amount of choice were higher. The teacher felt that there was more choice and difficulty in the differentiated assignments, but did not comment on the difference in depth. Finally, to compare the data on all three curricular levels, the perceived curriculum and attained curriculum match perfectly with respect to the ranking of the top two most influential elements, *choice* and *depth*. The teacher and students really were on the same page regarding these activities. With respect to the formal curriculum of the periodicity activity, the main elements provided by the activity did not match up well with either the teacher responses or the student responses. Similarly with the molecules activity, only the most influential element of *choice* and the least influential element of *difficulty* matched with the student and teacher responses.

Materials Analysis

There were two activities completed by this sample group titled "Periodiciteit in Breuken [Periodicity in Fractions]" and "Moleculen in Leven [The Molecules of Life]". The materials used for this sample group were designed by researchers at the University of Utrecht and tested previously on students in the same program. Therefore, it is assumed that the materials are valid as differentiated instructional materials.

The activity scores for the Periodicity in Fractions activity can be seen in Table 3 below. This activity was completed by two of the four students interviewed at the JCU (BS3 and BS4). As you can see in the table, *difficulty*, *depth* and the *ownership* over the product scored the highest as being the most prevalent elements in the activity. Conversely, the element of *choice* and the sub elements associated with it were not that prevalent, and it can be concluded that the assignment afforded more in terms of difficulty, depth, and product ownership in place of choice and process ownership.

Table 3: Rubric scoring totals for the Periodicity in Fractions activity

Element	Score (1-5)	Notes
Difficulty	5	4/4 criteria
Choice -Approach -Learning Mat'l -Solutions -Problems	 2 1 2 1	
Ownership -Process -Product	 2 5	
Depth	5	4/4 criteria met

The other two JCU students completed the activity 'The Molecules of Life', but BS1's group chose to focus on the drug Botox and BS2's group focused on the drug Vioxx. As seen in Table 4 below, the element of the choice was found to be the most prevalent in the activity.

Table 4: Rubric scoring totals for the Molecules of Life Activity

Element	Score (1-5)	Notes
Difficulty	2	1/4 criteria: complex/abstract
Choice -Approach -Learning Mat'l -Solutions -Problems	 5 4 5 4	
Ownership -Process -Product	 4 5	
Depth	3	2/4 used: interdisciplinary, extended concepts

Furthermore, the activity allowed lots of ownership over the final product. The elements of difficulty and depth were not so prevalent in this activity, as they only partly contained the criteria outlined in the rubric.

Interviews

Teacher Interview

The teacher (BT2) felt that all students had a strong topical interest in the subjects before they completed the activities. The teacher talked about how the time frame for the assignments wasn't adequate for the students to *really* get exposed to the material or get very deeply into it, but these activities do play a role in *maintaining* student interest.

The teacher also felt that the general interest in the activity was because the students wanted to 'learn more' and were generally positive about the activity, which matches up very well with how the students actually felt.

Concerning the four elements, for *difficulty* the teacher felt that the students were most interested by the fact that the assignments were a 'challenge' and 'hard' and believed the element of *choice* to be very influential in the interest of the students, stating:

BT2	.. the main thing people like about the differentiation assignments are not the assignments themselves, but the fact that are free to choose whatever they like, more or less.

He felt that the 'choice of approach' and the 'choice of assignments' were equally important in engaging the students, and that the presence of choice in the activities was what made them so attractive to the students.

In terms of *depth* the teacher did not compare the depth to a typical lesson or to the material learned at the JCU, however he did cite the 'deeper challenge/concepts' and 'choice of depth' as the most influential factors within the element of depth.

Interviewer	How do you think the depth plays a role into how interested they are?
BT2	It's the other way around, if they are really interested they go really deep, dig in.

Both teacher and students stated that the choice of depth influenced their interests, and both groups agreed that the choice of how deep to go stems from interest in the subject; the more interested a student is in the topic, the deeper he or she will explore that subject in the activity.

For the theme of student experience, the teacher felt that the students were mainly intrinsically *motivated* by their 'interest' in the subject and slightly extrinsically motivated by the pressure to complete the assignment. The teacher responses concerning intrinsic motivation match perfectly with student responses, the majority of students stating that their motivation source was due to interest in the subject matter of the activity.

The teacher mentioned recognition from other students as the most influential factor, but in general he didn't feel as if recognition was a major factor in the students' experience. The students, however, mentioned recognition from both fellow students and teachers to be an influential aspect in their experience during the activity.

Relevance was not mentioned by the teacher, or covered in the interview, yet students referred to 'future relevance' and 'relevance to school work' as the main factors influencing how they felt about the relevance of these activities.

Student Interviews

For the first theme, all of the students reported prior interest in the respective subjects (math and biology). When asked if the differentiated activities increased their interest, they said that their interest was neither increased nor decreased, but remained the same. Like the students at School A, this confirms interest in the subject.

Concerning the *difficulty* element of the activities, the students found the difficulty easier than a normal lesson at JCU*,* but more difficult than a lesson at their normal school. Within the realm of difficulty, the students really liked the fact that the activities presented a 'challenge', and that the material was 'built-up'; it increased with difficulty the further along they went in the assignment.

Interviewer	Why did you make it so difficult for yourself?
BS2	Mm, yea because I already understood the stuff from before [normal JCU lesson] really well, so I wanted something new and something challenging, and I did that for myself to bring in the challenge, and also my group partner, who did the project with me, they also wanted to do that [be challenged].

For *choice***,** all students agreed that these activities gave them more choice than in a normal JCU lesson. The main factors influencing choice for the students at School B was the fact that they could not only choose assignments, but also choose their plan of attack or 'approach' within an assignment.

BS4	So the fun thing was you could choose your own exercise and it turned out that we [the class] had chosen three different exercises and we [the class] had three totally different presentations. So it felt like we had something original because the other 2 groups that had done the same [assignment] didn't have the exact presentation.
BS4	…because it wasn't like "there's a question, and there's an answer", … [each exercise had] multiple ways you could solve it, and you would come to the same answer eventually but you would put them into the program, and you had to fiddle around and that's what makes it feel like you're doing it yourself.

In terms of *ownership*, the most common factor that interested the students was the fact that they got to make an original end product. They also felt it was nice to be able to choose not only what they learned, but how deep they wanted to go with the assignment.

Lastly, *depth* was also a major factor influencing the interests of the students.

BS1	Um, some subjects I like better than others, then I go deeper because it's something you like. Biology is one of the subjects. And subjects that you don't like as much, you don't need to go in as deep, because it's not required.

BS4	What I like in this specific activity is usually with differentiation is you can choose whether you want to get into it, like the basis, and then make a presentation about that, or get into it **even** deeper, or **even deeper**…

From the four main elements, the most influential was found to be the element of *choice*, with a 'choice of assignments' and 'choice of approach' the most influential factors. The second most influential element affecting student interest was the element of *depth*, with a 'choice of depth' being by far the most common response. This links up very much with the choice element, and is also afforded by the fact that the materials are very open and allow for this choice freely throughout the assignment. The full rankings can be seen in Table 5.

For the final key theme of student experience, students all agreed that if an assignment is too open-ended it is a big de-motivating factor.

BS2	And the toughest thing I think now and then is if you get a really open assignment like "ok research **something** about Botox"… So if you're sometimes so free that you don't know what you have to do…

Furthermore, *recognition* from both teachers and students was an important factor in their learning experience.

BS4	So I think it feels good to get [teacher] recognition, but also to see that other people did things while **you** were doing something pretty hard, that were equally as hard and then think, "whoa they did that." That's pretty impressive too. I think it's nice a circle of having respect for each other, I think it really helps.

In terms of the *relevance*, 2 students (BS1 and BS2) found their biology activity more relevant than BS3 and BS4. They found the activities more relevant to their school work and to their future/career goals. BS2 felt that the activities helped him understand material from the classroom more completely, and gave him a more well-rounded view of the biological concepts he learned.

Student Product Analysis

For the student products from School B, the students made posters, presentations, or both. While it was not possible to attend the student presentations for this group, the posters were collected and analyzed. Six posters were analyzed to determine if they adhered to the requirements of the activity, and to what degree the students incorporated a personal choice, originality, and increased depth or difficulty.

Using products from two students from that same class as BS1 and BS2, it was determined that the students did in fact incorporate all of the elements into their product. Two posters can be seen below in Figure 1 and Figure 2.

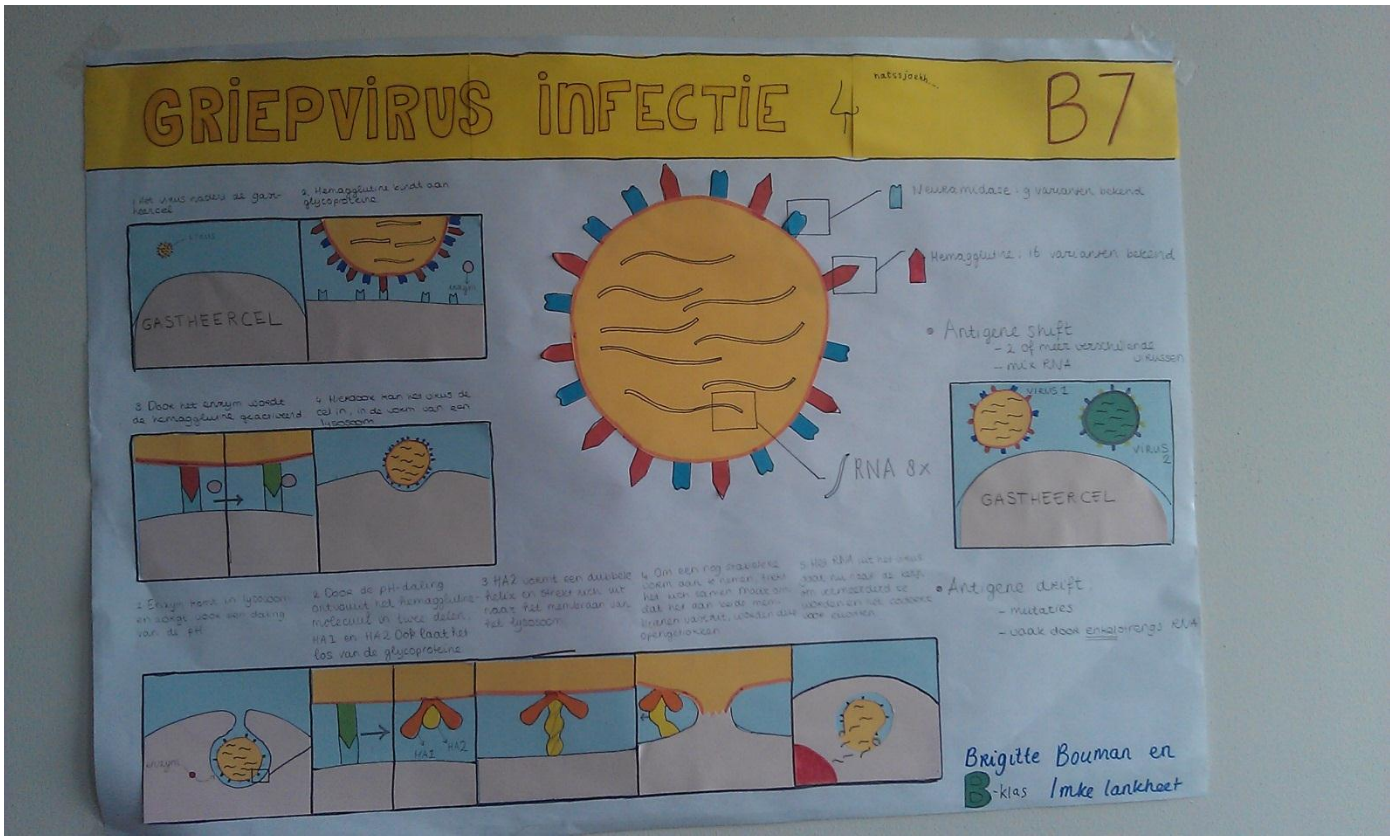

Figure 1: Poster about how the flu infects cells. Focused on process of infection

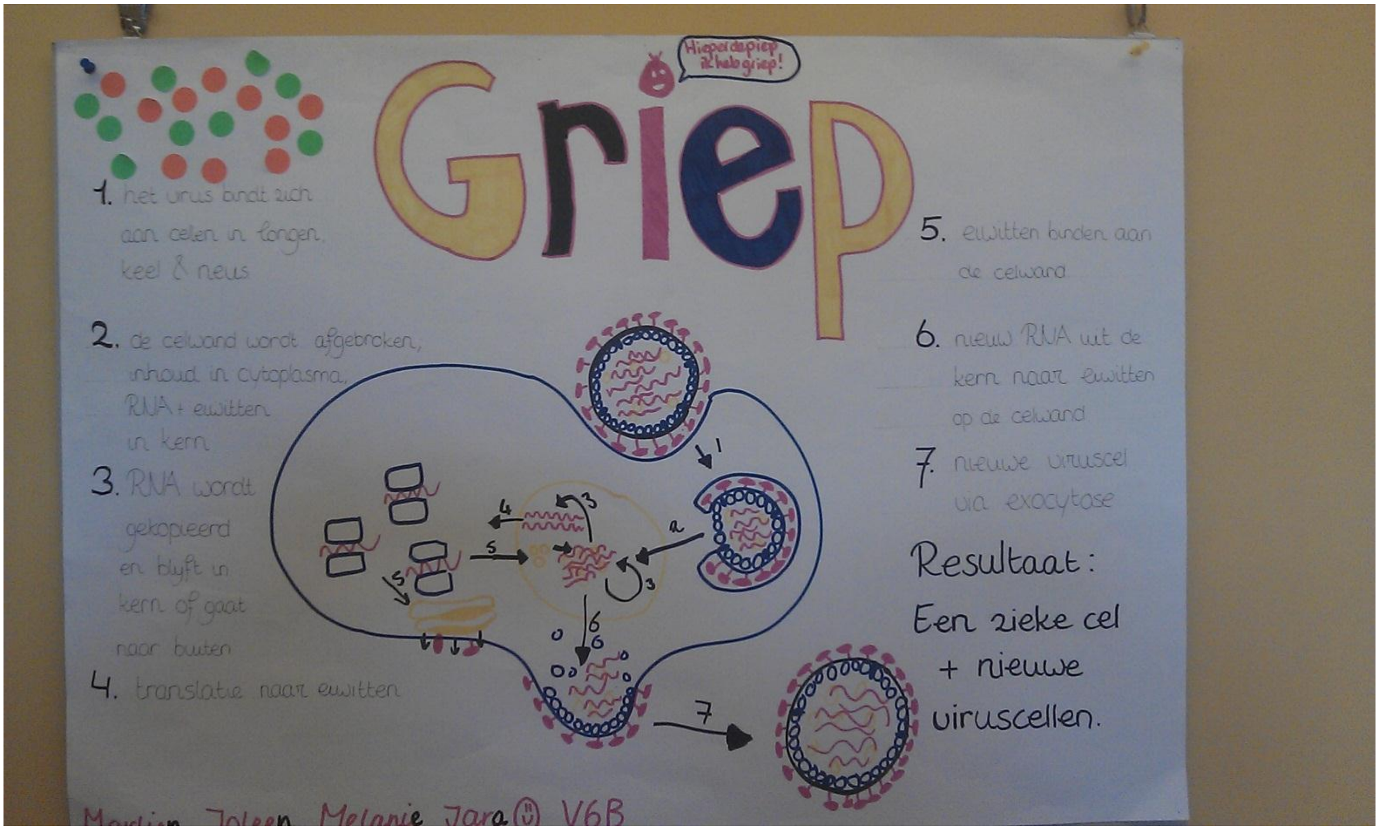

Figure 2: Poster about how flu cells replicate

As shown in the posters above, two separate groups working on the activity "Moleculen in Leven" chose to present the flu virus. The first group, whose poster is shown in Figure 1, chose to research *how* the flu cells bind to a host cell from a molecular standpoint. They dove deep into the material, and explained how the hemaglutine are activated by enzymes. The second group approached the topic from a different level, as seen in Figure 2. This group also talked about *how the virus reproduces,* but on a more basic level. Instead of focusing on molecular processes, their poster focuses more on the viral reproductive process as a whole.

These two posters are good examples of how all four of the research elements are present in the student products. The two groups of students both *chose* the assignment and topic, yet the *depth* in which each group researched the flu virus was different. The first group chose to go into more depth, and the *difficulty* of the material seems higher than the second group. Each group made an original poster – an original end product that can be linked to *ownership*.

It should be noted that the posters presented above were supplemented by a presentation, which may have included more information that is not shown by the posters. The students who made the posters were not interviewed, but were in the same class as students BS1 and BS2and completed the same overall assignment as they did.

Comparison – School B

For School B, the teacher and student responses matched up very closely; what the teacher perceived to interest the students did interest them in reality. Therefore the perceived curriculum corresponded almost perfectly with the attained, experiential curriculum. Only the specific factors/codes differed, while the ranking of important elements was spot on. At van den Akker's first level, the formal curriculum, materials analysis of the activities showed that for the Molecules activity, choice was the predominant element found in the assignment, with choice of approach one of the top factors. This is exactly what the students and teacher mentioned as important in influencing their interest in the activity. For the Molecules assignment, ownership of product and process was also determined to be a prevalent factor in the materials analysis; the assignment allowed students not only to create their own end product, but also to choose their learning process. This ownership over the process and product was stated as least influential to students however, although originality can be seen in the final products. Two student groups' posters covering the same topic (Griep, see figures above) focused on entirely different subject matter, demonstrating an original end product on the third curricular level. Finally, for the Molecules assignment, the elements of depth and difficulty were not prevalent in the materials analysis, yet the students and teacher ranked them as influential in generating student interest in the activity. For the Periodicity assignment, the materials analysis and the perceived and attained curricula do not match well. Depth is present as the most influential element provided by the activity in the materials analysis, and it is the second most influential according to the students and teacher. Table 5 below outlines the overall comparison for School B on van den Akker's curricular levels.

Table 5: Overall Ranking Comparison for School B on van den Akker's three curricular levels

Rank	Periodicity Activity	Molecules of Life Activity	Teacher	Students – Periodicity	Students - Molecules
1	Depth Difficulty	Choice	Choice (Choice of Assignments, Approach)	Choice (Choice of Approach, Problems)	Choice (Choice of Assignments)
2	-	Ownership	Depth (Choice of Depth) Difficulty (Challenge, Built-Up)	Depth (Choice of Depth)	Depth (Choice of Depth)
3	Ownership	Depth	-	Difficulty (Challenge)	Ownership (Process/Product)
4	Choice	Difficulty	Ownership (Product)	Ownership (Product)	Difficulty

School C – Revius Lyceum

The students from School C completed a differentiated pilot activity entitled "Moleculen in Beweging [Molecules in Motion]" nine months before the research was conducted. The students completed their second differentiated activity, entitled "Viscositeit: een maat voor stroperigheid [Viscosity: a measure of syrupiness]", shortly before being interviewed, and at the time of writing had not yet completed their final reports. The interviews focused mainly on the second activity, but students did occasionally refer to the first activity.

Summary

For School C it was found that the *depth* of the activity was the most influential element piquing student interest, followed by *difficulty, choice,* and *ownership.* Concerning the elements present in the differentiated materials (sub-question 1), the elements of *depth* and *difficulty* was the most influential in the activity, followed by *ownership* and *choice.* Concerning the teacher's perception of the students' interests (sub-question 2), the teacher found the element of *depth* to be the most influential on their interests, followed by *choice*, with *difficulty* and *ownership* tied for third. In general, the students found that the difficulty, depth, and amount of choice in the activity were more than they encountered in a normal lesson, while the teacher felt there was more depth and difficulty, but didn't comment on the amount of choice compared to a normal lesson. Finally, to compare the data on all three curricular levels, the most influential element affecting student interest for all three levels was *depth*. Furthermore, the two most influential elements from the materials analysis and the students' perspective were spot on, while the teacher's perception matched slightly with what the students thought.

Materials Analysis

The activity for School C had the students discover the formula for viscosity using experimentation and research. The activity was designed by the teacher, and was completed over multiple class periods or outside of class. The students used formulas provided by the teacher and through experimentation of objects falling through different liquids they determined the viscosity and other properties of the different liquids.

The materials analysis rubric was used to score the activity and determine which elements were present in the activity. The scoring for this activity can be seen in Table 6 below.

Table 6: Rubric scoring totals for the Viscosity activity

Element	Score (1-5)	Notes
Difficulty	5	4/4 criteria met
Choice approach LM Sol Problems Depth difficulty	 3 1 2 1 2 2	
Ownership Process Product	 4 -	
Depth	5	4/4 criteria met

As seen above, difficulty and depth were the most prominent elements provided by this activity, as well as ownership of the process. The activity allowed the students to figure out how they were going to solve the problems, and in the case of this sample group, they actually felt they discovered something new using their process.

Interviews

Teacher Interview

The teacher who was interviewed (CT3) agreed that the students all had prior interest in the subject of physics and that normal lessons were too easy for them. He thought the most common negative aspects of the normal lessons were boredom and repetition.

The teacher felt that the activity was interesting for the students because it gave them a lot of independence and also gave them the ability to ask more questions. He said that the activity increased student interest by challenging them and giving them information they did not receive in a typical lesson.

For the element of *difficulty*, the teacher felt that the most influential factor was the challenging nature of the assignment. He viewed the assignment as difficult, and found it more difficult in comparison to a normal physics lesson.

For the element of *choice*, the teacher stated that the 'choice of approach' was the most influential factor regarding choice. For him this choice was important in being able to think for oneself, and come up with a plan.

CT3	Yea they have a choice in how they attack it. [The activities] try to keep the choices open. So **not** like "do this, do this, do this." Instead – this is the assignment, come up with a plan of attack.
Interviewer	Why is it set up like that?
CT3	Because students need to learn themselves how to dive in and make their own thought process.

Much like the students, for the element of *ownership* he found the process to be the most influencing factor, stressing that it was built into the assignment for students to make the process on their own, which added to the sense of ownership.

The teacher thought activity was much deeper than a normal lesson, and found the 'multi-disciplinary' aspect the most influential to the students. He also said that the fact that the students learned entirely new concepts also added to the allure and interestingness of the activities.

Interviewer	…Ok so the depth is deeper than a normal lesson?
CT3	Yes, it is stuff you don't get in a normal lesson.
Interviewer	Why do they want to know that?
CT3	Because they are piqued to learn more and we tell them about it.

Of the four main elements, the teacher found the element of *depth* to be the most influential on the interests of the students. *Choice* was the second most influential element according to the teacher, with the 'choice of approach' the most influential factor in that field. Lastly, the teacher found *difficulty* and *ownership* the least influential on the interests of the students. A comparison of the ranking of elements can be found in Table 7.
In terms of student experience, the teacher felt that the students were intrinsically motivated by 'interest' in the activity, and did not mention any extrinsic motivation factors or demotivating factors. The teacher felt that the element of *recognition* was not important for the students, and also did not mention *relevance* as an interest factor for the students.

Student Interviews

The interviews mainly focused on the student's experiences with the more recent viscosity activity, but they did mention the molecules activity.

From the interviews it was found that all students exhibited a positive prior interest in the topic of physics before the activity began, and all students unanimously found normal physics lessons too easy.

For the theme of general interest in the differentiated activity, two students reported a slight increase in interest, while one student echoed the views of students at other schools.

CS1	Well my interest isn't changed or something, it just remains the same. I just like all the info I got.

The most common general reasons for interest in this activity were being able to ask a lot of 'questions' and gaining 'more knowledge'. The students also really liked the feeling of accomplishment they had when completing this assignment.

Concerning the *difficulty* element, the students agreed that it was more difficult than a normal lesson, but became easier as they became acquainted with the activity.

CS1's positive experience stemmed from the fact that he was able to ask more questions and had more individual attention, while the other two students enjoyed the challenging nature of the assignment, and its increased difficulty compared to normal lessons.

Interviewer	And what do you guys [to CS2 and CS3] think of that? Do you like that it was more difficult
CS2	Yea I kind of liked it because it gives you…
CS3	It's more of a challenge.
CS2	Yea, and after you understand it, it feels way better also
Interviewer	What do you mean feels better?
CS2	Like um…
CS1	The feeling that you have accomplished something.
CS3	Yea!

For the element of *depth*, the students all agreed that this was deeper than a typical physics lesson and required new skills and concepts, which matches with the materials analysis. The most common response for factors influencing the interest was the multi-disciplinary aspect of the lesson. CS2 enjoyed how they were able to determine the viscosity of blood while CS1 talked at length about how he felt interdisciplinary aspects were important because they give you a more complete picture of world.

Regarding the element of *choice* in the activity, the most common by far was the fact that they were allowed to choose the approach, and plan out how exactly they wanted to tackle the problems in the assignment.

CS3	I usually feel during normal lessons when we do experiments, that it's useless because um, you get a list of what you have to do, instead of thinking of it yourselves, so it's, I think, "what I do I learn from this?"
Interviewer	Why?
CS3	Because I feel, why should I do this, why should we do this when, it's already given what we have to do.
CS2	Yea and then you can think yourself instead of blindly following the paper.

This quote solidifies how the students disliked normal lessons because of the repetitive nature of experimentation and preferred activities where they could devise their own procedure or plan of attack.

Regarding *Ownership,* the feeling of ownership over the 'process' and a feeling of 'discovery' were the two most common factors. This is in line with the set-up of the activity, which allowed the students to create their own process for the experimentation.

The final theme of student experience was analyzed, with elements of *motivation*, *recognition* and *relevance*. The main motivating factor to participate in the activities (and the beta-excellence program) was that it was a requirement to apply to the JCU. The fact that they wanted to participate in the JCU also supports the fact that they wanted more in their science education, and wished to further their learning with an outside science program.

They also stressed the importance of enough prior knowledge, or introductory material, which was important to prepare them for the assignment, so they were not in over their heads when they began the activities.

Recognition was important and often mentioned by the students, but the forms of recognition were equally split between 'teacher recognition', 'student recognition', and 'being part of a select group'. The students did stress, however that they didn't participate for recognition, but because they were interested and wanted to learn more, and wanted an opportunity to apply to the JCU.

Comparison – School C

Table 7 below shows the full ranking of the four main elements on all three curricular levels. As shown in the table, all three levels show *depth* as being the most prominent element, with the 'multi-disciplinary' aspect being influential according to both teacher and students.

Table 7: Ranking of Influence of Elements for School C. Most common responses/factors are in parentheses

Rank	Viscosity Activity	Teacher	Students
1	Depth Difficulty	Depth (multi-disciplinary, different concepts)	Depth (multi-disciplinary)
2	-	Choice (Choice of approach)	Difficulty (Challenge/Hard)
3	Ownership	Ownership (Process) Difficulty (Hard, Challenge)	Choice (Choice of approach)
4	Choice	-	Ownership (Process, Discovery)

Although the ranking of the elements for teacher and students is slightly mismatched, the fact that the most important factors are all the same shows that the teacher's perception of what interests the students closely matches their actual feelings, and is in line with the scope and goals of the activity itself. Both the teacher and students felt that the 'choice of approach' was the most interesting factor regarding choice.

While the teacher and student responses agreed for the most important element, the teacher felt that the difficulty was the second most influential factor whereas the students preferred the choice they had in the assignment. The teacher felt that the assignment was difficult for the students, who were mixed in their feelings of difficulty. They agreed it was more difficult than a normal lesson, yet still felt it was fairly easy to complete. Whether or not the activity was difficult from an absolute standpoint, the students appreciated the extra challenge, which the teacher also felt had an impact on their interest in the activity.

Interestingly, the materials analysis yielded a low ranking of choice as being present in the activity, yet the teacher ranked it as second most influential. Perhaps this is due to the fact that he perceived the choices contained in the assignment as more influential than they actually were. Regarding choice, the students were also wary about the downside of *too much* freedom present in an assignment. They mentioned their first activity, "Molecules in Motion", was too open and lost them completely.

In sum, the data for School C matches moderately when compared across all three curricular levels. The most influential element of depth was the same for all three levels, and difficulty matched well for levels one and three. Beyond that the element rankings varied, but it should be noted that the teacher recognized the exact same influential factors that the students mentioned for all four levels.

Discussion

This research was conducted to determine which elements of differentiated activities added most to the interests of talented high school students. The broad aim was to add to the empirical research base concerning talented students, and also to give insight to differentiated material designers on what students like and dislike about differentiated assignments. While the data from this research corresponds nicely on the three curricular levels, the research is not without its limitations.

First, limitations exist concerning the samples in this multiple case study; which can affect how the data may be generalized to other situations. The research was conducted using three sample schools and a small sample population of eleven students. This low number of respondents was mainly due to scheduling and logistical issues. Additionally, there were four separate activities that were all conducted in various settings. Two of the schools (A & C) were normal, mixed ability schools with the activities performed during class time but in a separate room, or after school. For both schools, these were the first differentiated assignments the students had ever completed. School B on the other hand was a special case - the students were already outside of a normal classroom environment, in a setting with only gifted students, who did multiple differentiated activities per year. One final note on the limitations of the sample students is to recognize that due to logistics, not all students could be tested to determine if they were truly gifted. To that end, the choice was up to the teacher to pick students they saw as talented. This is especially valid for school A, where the selected students were chosen by the teacher (See Sample section). In general the selected students were seen as the most talented students in their respective classes.

Second, there were limitations with the data collection and analysis. The interview scheme was tested with colleagues but not with real students. The interview scheme was structured and was followed for each interview situation, making it a reliable tool for future research on this topic. The coding of the interviews was only performed by one person, meaning there is no inter-rater reliability, and discrepancies in the coding may be present. Finally, the student products for School C were never received, and therefore never analyzed. The qualitative nature of this research might also raise some questions as to the validity of the results. The coding from the interviews leads to quantitative results which answer the research question, the lack of a second coder reduces the validity and reliability of the data analysis.

Despite the limitations, the findings from this research support previous theory that differentiation is a valid means to engage and interest talented students in high school science classes. Furthermore, this research pinpointed elements that the students found most interesting. While each school had individual results based on the activity and sample group, many connections can still be made between the groups. One of the most common responses concerning the general interest of the activity was to ‘learn more’. All students were not only motivated to learn more, but also enjoyed the fact that the differentiated materials gave them something extra. This is also inherent in the theory surrounding talented instruction, as talented students strive to learn more that they are given in a normal lesson (VanTassel-Baska, 2002). Additionally, the activities each differentiated based on content, process, product, or a mix of the three as Tomlinson outlines (2003; 2001), and the elements which interested the students corresponded to the differentiated elements prevalent in each assignment.

Additional similarities include the fact that 'depth' and 'difficulty' were present the top two most important elements for all the student samples. All students across all three samples did agree that both the difficulty and depth of the differentiated activities was higher than what they would learn in a normal lesson, and cited these as influential factors for their increased interest in these differentiated assignments. Furthermore, all students wanted to gain more knowledge. Whether or not students felt bored with a typical curriculum, which was usually the case, they felt more challenged and interested with the differentiated activities because it allowed them to learn more about something they did not previously know. This connects well and supports prior theory that talented students are known to want more complex, difficult and abstract problems (VanTassel-Baska, 2002; Tomlinson, 2001)

In a global sense, these student responses validate and reflect what was found in the literature review and shed light onto what specific characteristics students find interesting in differentiated materials. All in all it seems that student responses and feelings were very dependent on the activity itself. For example, activities with little choice associated with them elicited few choice-related responses from the students who completed that activity. Conversely, for students who completed very open ended, choice based assignments, their interest was most significantly stimulated by that particular aspect. Most student and teacher responses regarding choice reflect what was found in the literature review, especially Chamberlin (2011), Nunley (2003), and Tomlinson (2001).

Interestingly, ownership was not seen as a major influential element across all samples. Perhaps the concept of ownership was described poorly and misunderstood by students, but in all cases they did not feel that an original product or process added to the interestingness of the activity. As students at School A mentioned, they didn't feel as if they were doing an original activity; they knew someone had completed this before them. They didn't see the guided reinvention in the activity as a personal triumph, or a facet that could be attributed to ownership over the activity. For this group of 13 year olds, the *definition* of ownership was different because of the fact that they didn't completely invent the situations in the activity.

The inclusion of the theme of student experience (*motivation*, *relevance* and *recognition*) also yielded some interesting outcomes. *Recognition* was also shown to have positive effects on many of the students. In fact, one teacher and one student from two separate school stressed how important recognition actually is. One student at School B stated, "What I think does help, recognition from the teachers, is that they know, that you want to know more." Similarly, the teacher at School A said, "…and also the fact that they feel, they feel noticed, I think that's pretty important too - **they know** that **you know,** that they're way beyond what we're doing now." The student experience seems to be lost in the mix sometimes, yet these intangible aspects of a lesson can make a big difference in the teaching/learning environment.

Finally, it proved to be very useful to analyze the activities on the three curricular levels of Jan van den Akker (1998). By comparing the formal, perceived, and experiential curriculum, it could be easily compared how the different participants (activity designers, teachers, students) perceived the differentiated instruction. This research found that on the whole, the teachers and students were pretty much on the same page as the designers, as all three levels matched fairly well. As a final note, all students were very positive about the activities, and interest was confirmed across three samples. Perhaps this is due to the fact that the first two curricular levels were in line – a well-organized and/or designed activity that is implemented correctly by a teacher will result in student experiences and feelings that are in line with the intentions of the teacher and designer.

Conclusions

The purpose of this research was to determine what elements talented students found most influential to their interests regarding differentiated assignments. Prior research indicated that differentiation was a valid intervention for gifted students, and outlined how the differentiated curriculum should be implemented for G&T students. However, little empirical evidence was found regarding what aspects students were most interested by. Therefore, the main research question was: "*Which elements of a differentiated activity add to the students' interest in that topic and to what degree?*"

The main elements include *choice*, *difficulty*, *depth* and *ownership*. Secondary elements included the student experience elements of *motivation*, *relevance* and *recognition*. To further analyze the data, additional variables were looked at, including a differentiated material analysis to see which elements were present in each assignment and to what degree, and the teachers' perceived views on which elements interested the students the most. These variables were compared on van den Akker's three curricular levels to see what the activities provided for the students, what the teachers thought interested the students, what actually interested the students, and finally how the students presented their final products.

From this research it was found that while the most interesting elements varied depending on the group, within each sample the elements corresponded well on van den Akker's three curricular levels. The activity provided for certain elements, which both the teacher and students saw as influential to student interest. Interestingly, if the activity provided for a certain element more than others, students usually found that to be most interesting. It makes sense, since one won't be interested in something that isn't there. But this is an important point to consider, especially for teachers who choose the activities. If activities are consistently chosen that heavily favor one or two elements, say choice and depth, students might miss out on other activities that give them more ownership or depth, for example.

One of the most common responses of all students concerning differentiated activities was to learn more. All students were unanimous in agreeing that their interest was never really increased by the activities, but was however confirmed, as students were just as interested in the topics after the activity was over. To paraphrase the teacher at School B, these activities are performed in four or five lesson hours. It isn't enough time to really dive deep into the subject matter, but at least it gets the students thinking and keeps the topics at the front of their brain. This links with the general feelings of all the students; they all liked how the activities were more difficult and deeper, as most of them were bored with normal lessons on the subject. Even if student interest wasn't increased, at least the students are working with the content, in a deeper, more meaningful way, for longer periods of time. This also connects to Dohn's research (2010), which looks into how situational interest can be molded into long term interest. In this case, the students are working with an activity for longer, and maintaining their interest in the subject, which can lead to a more established personal interest in the subject.

While students did not mention many downsides of the differentiated activities, one disadvantage that was echoed by all students was to avoid activities that are too open. When students were given too much freedom, they became confused and uncertain of what to do. Thus, scaffolding by both the activity and the teacher is necessary to keep students on track, especially when students are graded on the final product.

In sum, the results from each school were very dependent on the activity itself, yet in almost all cases the elements that were provided by the activity were usually the ones that had the most influence on the students' interests. In most instances the teachers were on the same page as the students, as their responses lined up well with the responses of the students. There were mixed responses about the student experience theme, as relevance and recognition are personal qualities that vary from student to student. In almost cases however, students agreed that even if an activity wasn't relevant, they still enjoyed doing it, because it addressed their thirst for more difficult and deeper assignments. The same is true for an increase of interest – the activities didn't necessarily increase student interest in the topic, yet maintained interest, and perhaps even more importantly, confirmed the prior interest of the students. All students from schools A and B also generated end products which showed deeper though, difficult concepts, many aspects of choice, and original products and processes. The students excelled when they were given the chance to perform these activities. Furthermore, results form this research echoed the theories of Schiefele (1991), which stated that people will naturally be attracted to things that interest them. Students at School B felt the most important part of the activities was that if the activity interested them, they could go as deep as they wanted, and really delve into the project. Students at School C felt similarly, and were really interested in the part of the activity that was meaningful or interesting to them.

For talented students who feel bored in a normal classroom, the recognition from teacher to student that they are beyond the normal material and deserve more of challenge can be a great motivator to students who just want something deeper and at a higher level. These students **are** interested in the subject matter, and once engaged, they work hard to complete the activities and produce meaningful final products. While the elements that interest them depend on the activity, the students are interested and have a thirst for more knowledge - knowledge that can be provided by a well-designed activity and an experienced teacher.

Recommendations

It is clear from this research that educators on many levels can benefit from differentiation. This research has shown that differentiated activities are a valid and useful intervention for talented students in mixed ability science classrooms. Furthermore, this research has pinpointed not only exactly *what* talented students find interesting regarding these types of activities, but also *how* their interests relate to the perceptions of teachers and educational material designers. Recommendations can be made on all three levels of van den Akker's curriculum. These levels are the formal curriculum (activity designers), perceived curriculum (teachers), and attained curriculum (students).

As a designer, it is important to ensure that the assignments regarding student choice are not too open. All students interviewed for this research agreed that when assignments were too open it became frustrating and demotivating. Students cited a lack of direction and scaffolding as the number one turnoff for them. Conversely, they do think that more types of activities covering a broad range of topics from which that can choose will positively address *their* differences in interests and learning styles.

As a teacher, it is important to provide the proper background knowledge for students to complete the activities. Certain activities, especially interdisciplinary or enriching activities, might require skills that were not learned in class. Moreover, clear student expectations are important, especially for activities that require multiple processes and products. If there is a grade involved, students want to know exactly what they need to do and what is expected from them concerning grading. While this sounds like common sense, students who are completing assignments involving a lot of choice in process, product, or depth, want to know exactly how they will be graded, and what the ramifications are if their research/experiment might fail.

As a recommendation for further research, it would be interesting to know how the modified learning environment affects the independence and outcomes of the students. This research focused on students from mixed ability classrooms, but in actuality, all three samples were special cases: School A performed the activity during class hours but outside of the class room, School B is a gifted program taking place entirely outside of the normal classroom, and School C was similar to School A, except they also worked after school in addition to during class hours. It was not a goal of this research but to see how modified learning environments affect independent learning and outcomes would back up the research of Tomlinson, et. al. (2003) and Berger (1991).

Acknowledgements

I would like to thank my advisor Ton van der Valk for his help, guidance, and most of all patience in all aspects of this research. I would also like to thank Dirk Jan Boerwinkel and Arthur Bakker for their support and guidance with the research process. To the students at Revius Lyceum, Het Nieuwe Lyceum, and the JCU, thank you for taking the time to interview with me, without you guys this research wouldn't have been possible. Thank you to the participating teachers, Ralph Meulenbroeks, Jeroen van Velden, and Jaap Hillebrand, who took time to interview and set up everything with the students.

I also want to thank Marloes Vrolijk, Karen van Meeteren, and Jan te Roller for their help in checking my interview transcriptions and translations. Also a big thanks to my mom for doing an amazing last minute grammar review of the final paper, and to my dad for his input. To my family and friends who listened to me complain for the last year – sorry!

Works Cited

Beecher, M., & Sweeny, S. M. (2008). Closing the Achievement Gap with Curriculum Enrichment and Differentiation: One School's Story. *Journal of Advanced Academics, 19*(3), 502-530.

Berger, S. L. (1991). *Differentiating Curriculum for Gifted Students.* Reston, VA: CEC/ERIC. ED 342 175. Retrieved July 27, 2012, from http://www.vtaide.com/png/ERIC/gifted-currDiff.htm

Chamberlin, M. T. (2011). The Potential of Prospective Teachers Experiencing Differentiated Instruction in a Mathematics Course. *International Electronic Journal of Mathematics Education, 6*(3), 134-156.

Davis, G. A. (2002). Identifying Creative Students, Teaching for Creative Growth. In N. Colangelo, & G. A. Davis, *Handbook of Gifted Education* (3rd ed., pp. 311-324). Boston: Allyn & Bacon.

Dohn, N. B. (2010). Situational interest of high school students who visit an aquarium. *Science Education, 95*, 337-357. doi:10.1002/sce.20425

Evans, C., & Waring, M. (2011). How can an understanding of cognitive style enable trainee teachers to have a better understanding of differentiation in the classroom? *Educ Res Policy Prac, 10*, 149-169. doi:10.1007/s10671-011-9101-1

Gubbins, J. E. (2003). *NRC/GT: Assessing Instructional and Curricular Strategies.* Retrieved from Neag Center for Gifted Education and Talent Development (University of Connecticut): http://www.gifted.uconn.edu/nrcgt/newsletter/fall03/fall031.html

Hall, T. (2002). *Differentiated Instruction: Effective Classroom Practices Report.* National Center on Accessing the General Curriculum.

Hall, T., Strangman, N., & Meyer, A. (2003). *Differentiated Instruction and Implications for UDL Implementation: Effective Classroom Practices Report.* NCAC. Retrieved August 1, 2012, from http://aim.cast.org/sites/aim.cast.org/files/DI_UDL.1.14.11.pdf

Hulleman, C. S., & Harackiewicz, J. M. (2009, December 4). Promoting Interest and Performance in High School Science Classes. *Science, 326*, 1410-1412. doi:10.1126/science.1177067

Kondor, C. A. (2007). *One Size May Not Fit All, But the Right Teaching Strategies Might:The Effects of Differentiated Instruction on the Motivation of Talented and Gifted Students.* Masters Thesis, Portland State University, Portland.

Krapp, A. (1999). Interest, motivation and learning: An educational-psychological perspective. *European Journal of Psychology of Education, 14*(1), 23-40.

Logan, B. (2011). Examining differentiated instruction: Teachers respond. *Research in Higher Education Journal, 13*, 1-14.

Nunley, K. F. (2003, September). Layered Curriculum Brings Teachers to Tiers. *The Education Digest*, pp. 31-36.

Reis, S. M., & Fogarty, E. A. (2006). Savoring reading, schoolwide. *Educational Leadership, 64*(2), 32-36.
Robinson, A. (2002). Cooperative Learning and High Ability Students. In N. Colangelo, & G. A. Davis, *Handbook of Gifted Education* (3rd ed., pp. 283-292). Boston: Allyn & Bacon.
Saldanha, W. M. (2007). *The Effects of Differentiated Instruction in High School Science.* Atlantic International University.
Schiefele, U. (1991). Interest, Learning, and Motivation. *Educational Psychologist, 26*(3 & 4), 299-323.
Schiever, S. W., & Maker, C. J. (2002). New Directions in Enrichment and Acceleration. In N. Colangelo, & G. A. Davis, *Handbook of Gifted Education* (3rd ed., pp. 163-173). Boston: Allyn & Bacon.
Sternberg, R. (1997). What does it mean to be smart? *Educational Leadership, 55*(7), 20-24.
Sternberg, R. J., & Grigorenko, E. (1997). Are cognitive styles still in style? *American Psychologist, 52*, 700-712.
Subban, P. (2006). Differentiated Education: A Research Basis. *International Education Journal, 7*(7), 935-947.
Tomlinson, C. A. (1997, May). The do's and don'ts of instruction: what it means to teach gifted learners well. *Instructional Leader*.
Tomlinson, C. A. (2001). *How to differentiate instruction in mixed ability classrooms* (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.
Tomlinson, C. A., Brighton, C., Hertberg, H., Callahan, C., Moon, T., Brimijoin, K., . . . Reynolds, T. (2003). Differentiating Instruction in Response to Student Readiness, Interest, and Learning Profile in Academically Diverse Classrooms: A Review of Litreature. *Journal for the Education of the Gifted, 27*(2/3), 119-145.
van den Akker, J. (1998). The Science Curriculum: Between Ideals and Outcomes. In B. J. Fraser, & K. G. Tobin (Eds.), *The International Handbook of Science Education* (pp. 421-447). Dordrecht, The Netherlands: Kluwer Academic Publishers.
van der Valk, A. E., Grunefeld, H., & Pilot, A. (2010). Empowerment en leerresultaten bij getalenteerde bétaleerlingen in een verrijkte onderwijsleeromgeving [Empowerment and learning results of talented science students in an enriched learning environment]. *Pedagogische Studiën, 88*, 73-89.
van Dijk, V., van Velden, J., Meijer, F., & van der Valk, T. (2010, September). Tegemoetkomen aan verschillen in de klas: Keuzeopdrachten bij natuurkunde als voorbeeld [Responding to differences in the classroom: Choice of assignments in physics as an example]. *NVOX*, pp. 308-310. Retrieved from http://jcunieuws.files.wordpress.com/2010/09/tegemoetkomen_verschillen.pdf
VanTassel-Baska, J. (2002). What Matters in Curriculum for Gifted Leaners: Reflections on Theory, Research and Practice. In N. Colangelo, & G. A. Davis, *Handbook of Gifted Education* (3rd ed., pp. 174-183). Boston: Allyn & Bacon.
VanTassel-Baska, J. (2012). Analyzing Differentiation in the Classroom: Using the COS-R. *Gifted Child Today, 35*(1), 43-48. doi:10.1177/1076217511427431

Appendix A - Interview Scheme (Dutch)

Introductie

- Welkom en bedankt
- Onderzoeksdoel
  - bepalen wat een student's interesses zijn als hij/zij gedifferentieerde materialen gebruikt. Ook in hoeverre bepaalde aspecten van de activiteiten de meeste invloed hebben op de interesses van de student.
  - uiteindelijk de materialen verbeteren, theorie versterken
- Confidentiality – persoonlijke gegevens worden anoniem behandeld, namen worden niet gebruikt

Kun je me vertellen wat jullie hebben gedaan met je ___________ activiteit?
Houdingen over de gedifferentieerde activiteit - electronics

- Was je geïnteresseerd in de huidige topic ______ voordat je met de activiteit begon?
- Heeft de activiteit je interesse in de topic veranderd (verhoogd of verminderd)?
- Wat vind jij leuk aan de topic _________ en hoe bevordert de activiteit jouw interesse in de topic?
  - **DIFFICULTY**: Hoe moeilijk vind je de leerstof in de activiteit over de topic (Ben je meer/minder geïnteresseerd)?
    - Is hierdoor je interesse veranderd?
  - **CHOICE**: Wat betreft deze activiteit, denk je dat jij een keuze had om de leerstof of het leerproces te kiezen? (bv: mocht je kiezen welke concepten je ging leren, of welke opdrachten je wilde afmaken, of de manier waarop de leerstof geleerd werd?)
    - Is hierdoor je interesse veranderd?
  - **DEPTH**: Hoe vind je de diepgang (depth) van de leerstof die je tijdens de activiteit leerde?
    - Is hierdoor je interesse veranderd?
  - **OWNERSHIP**: Toen jij de opdracht (of huiswerk) maakte voor de activiteit, had je het gevoel dat jij iets origineels had gemaakt, of een origineel denkproces had gebruikt? (ownership)
    - Is hierdoor je interesse veranderd?
- Welke aspect(en) van de activiteit vind je het beste? Het slechtste?
- Denk je dat dit topic relevant is voor jouw dagelijks leven? Voor je toekomstige leven?
- Vond je de activiteit saai? Welke aspecten?

Motivatie

- Ik wil het nu hebben over je motivatie in de les en voor de activiteit
    - Wat motiveert je om meer te leren in dit vak (bv: cijfers, concurrentie, eigenbelang)
    - Wat motiveert je om je best te doen?
    - Wat motiveerde je om aan de slag te gaan voordat je met deze electronics activiteit begon?
    - Tijdens de activiteit, wat was jouw motivatiebron?
        - Werd je gemotiveerd door de volgende dingen: de keuze in leerstof, de keuze in het product/leerproces, diepte van de leerstof, moeilijkheid van de activiteit, ownership – origineel denkproces, origineel eindproduct
        - Wat vond je het meeste motiverende aspect?
        - Verder nog iets?

Vergelijking:
Welk aspect van de activiteit denk je dat het meest invloed heeft gehad op je interesse in deze topic (dus electronics/digitale signalen in het algemeen)?

Denk je dat je de leerdoelen van de activiteit heb bereikt vergeleken met de verwachtingen van je docent of je eigen verwachtingen.
Hoeveel informatie moest je opzoeken, en hoeveel wist je vanuit je hoofd (of van een vorige les)?
Feedback over de activiteit?
afsluiting

- Bedankt
- Samenvatting van antwoorden
- Verder nog iets?
- Ik ga met deze antwoorden een enquête maken om concretere data te verzamelen – willen jullie meedoen? E-mails?
- alles wordt vertrouwelijk behandeld. Willen jullie de resultaten wanneer ik klaar ben? (in het Engels)

Appendix B - Interview Coding Scheme

Version 4: July 20th 2012

Legend:
+: increased (or deeper, more difficult, more ownership, more choice)
-: decreased (less deep, easier, less ownership, less choice)
0: stayed the same
Suffixes: pos (positively affected)
neg (negatively affected)

#	Key themes	Theme	Label	Codes
1	General Interest			
1.1		Prior Interest		
1.1.1			Topical	Pos, neg, 0 (interest level: liked disliked, neutral) PRA (practical, make things) F (want to have a future) EXP (explore how things work or are explained)
2	Normal Lesson			
2.1		Structure		
2.1.1			Difficulty	EASY HARD LINK (+,- provides/doesn't provide previous knowledge for assignment)
2.1.2			Negatives	B (bored in normal lesson) FF (finished fast) REP (repetitive problems, concepts, approach) ND (not deep material)
2.1.3			Positives	ENV (environment – with friends)
3	Differentiated Activity			

3.1		Interest in Activity		
3.1.1			Change in interest	(+),(-), (0)
3.1.2			General Reasons	PRA2 (practical, make things) EXP2 (explore how it works) IND (independence from teacher/class) MK (more knowledge) – not related necessarily to diff/depth always ACC (accomplished something, results) Q (ask a lot of questions)
3.1.3			Downsides	TO (too open free) EXTRA (extra work) BOR (boring)
3.2		Structure: Aspects/Elements		
3.2.1			Difficulty	COMP (compared to normal +,-,0); EASY (level of difficulty) HARD (level of difficulty) CH (like a challenge) BU (built up) CDIFF (choose difficulty)
3.2.2			Choice	COMP (+,-,0) SOL (choice of solutions) PROB (choose problems) ASSN (choice of assignment) LM (choice of learning material within a subj.) CA (choice of approach/product/plan)
3.2.3			Ownership	PROC (original process) PROD (original product) DISC (discovery of something new, not)
3.2.4			Depth	COMP (comparison +,-,0)

				DIFF (different concepts) DC (deeper challenge/concepts/go deeper) RL (real life aspects) MD (multi-disciplinary) BU (built up) CDEPTH (choice of depth)
4	Student Experience			
4.1		Motivating Aspects		
4.1.1			Intrinsic	INT (interest) REC (recognition) FUT (either future goals or career goals) CHAL (challenging)
4.1.2			Extrinsic	GR (grades)
4.2		Demotivating Aspects		
4.2.1			Intrinsic	BUSY L (lack of confidence/ knowledge)
4.2.2			Extrinsic	
4.3		Feelings		
4.3.1			Recognition	TEA (from teachers) / STU (from students) / SEL (part of a select group)
4.3.2			Relevance	R (relevant to daily life) RS (relevant to school work) NR (not relevant) F (future relevance)

Appendix C - Rubric for Scoring the Differentiated Activities

Element \ Score	1	2	3	4	5
Difficulty	Activity has 0 of the 4 difficulty criteria (see below)	Activity has 1 of the 4 difficulty criteria (see below)	Activity has 2 of the 4 difficulty criteria (see below)	Activity has 3 of the 4 difficulty criteria (see below)	Activity has 4 of the 4 difficulty criteria (see below)
Choice	There was no provision to choose the approach/learning material/solutions/problems/depth/difficulty	There were few options to choose the approach/ learning material/ solutions/problems/ depth/difficulty	About half of the approach/learning material/solutions/problems/depth/difficulty could be chosen	More than half of the approach/learning material/solutions/problems could be chosen	Almost all of the approach/learning material/solutions/problems involved a choice
Ownership	There was no provision for original process /product	There were few opportunities for an original process/ product	The assignment provided for an average amount (50%) of original process/ product (~half of the end product or process could be original)	There were many opportunities for an original process/ product (~75% of the end product or process could be original)	Almost all or all of the assignment provided for an original process/ product (all of the end product or process could be original)
Depth	The activity contains 0 of the 4 depth criteria	The activity contains 1 of the 4 depth criteria	The activity contains 2 of the 4 depth criteria	The activity contains 3 of the 4 depth criteria	The activity contains 4 of the 4 depth criteria

Difficulty Criteria: The assignment contained/required
Abstraction/complexity, quantify/measure, apply in a context, *more* skills/multifaceted approach needed
Depth Criteria: The assignment contained/required
New concepts, extended concepts, *new* skills needed, interdisciplinary