Master thesis

Context-based learning

What happens with the learning activation and engagement of students when a chemistry lesson is context based?

Jaella Geerdink- Klink
S1726625

Supervisors
Susan McKenney
Susan.mckenney@utwente.nl

Talitha Visser
t.c.visser@utwente.nl

University of Twente
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Faculty of Behavioral, Management and Social Sciences, Master Educational Science and Technology, University of Twente, Enschede, The Netherlands.

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Abstract

Since 2003 the chemistry education is challenged to work towards a renewal of the current curriculum since the Commissie Vernieuwing Scheikunde gave the advice to use contexts to enhance the learning process on thinking in concepts. Learning via context should enhance students' motivation and their knowledge on the nature of chemistry. This research is carried out in the context of the IMPULS study which is an initiative of the University of Twente and funded by the Dutch ministry of Education, Culture and Science, and over a period of two years the aim is to co-design a chemistry curriculum for secondary schools that works towards better understanding of chemistry content with the use of a context. This research will aim for answering the question if the context-based lessons change the learning activation of students, on the levels of competency beliefs, fascination and values, and the engagement of students during the chemistry context-based learning (CBL) lessons. Two answer the abovementioned question, four research questions will be addressed during this research: *"What characterizes learning activation in CBL and regular chemistry lesson?", "What levels of engagement are observed during the CBL lesson?"," What opportunities to engage and learn are observed in the CBL lessons?" and "In the CBL lessons, what relationships appear to be present between learning activation, engagement, and opportunities to engage and learn?"*. A mixed-method approach was performed where questionnaires provide inside on the students' learning activation and to determine if the context-based lesson caused an effect on their learning activation. Student focus-groups, interviews and classroom observations helped to collect data on the engagement and opportunity to engage and learn during the context-based lessons. Results showed that between the experimental and control group no statistical differences were measured on learning activation and therefore no assumptions can be made regarding the influence of the CBL lessons on learning activation. The experimental group showed differences in attitude and perception in learning activation on the levels of fascination and values after the CBL lesson and this research revealed that the levels on fascination and value perception increased after receiving the CBL lesson. The qualitative data during this research led to implications for improvement of the CBL lesson materials such as; language level, sort of material and the duration of the CBL lessons. Further research could examine more information by researching the benefits and learning outcomes over a longer period with a larger sample of respondents. The conceptual research model underlying this study assumed that learning activation and engagement influenced each other, and that engagement was influenced by opportunity to engage. Research revealed that learning activation is also influenced by opportunities to learn and engage. The findings of this research and existing literature on context-based learning show that the chemistry CBL lesson approach can stimulate students' learning activation and engagement level.

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Acknowledgement

It is a wrap! The final piece of my master study Educational Science and Technology at the University of Twente is finished. The study thought me so much in de field of education and made me realize that if you work hard enough, dreams may come true.

I want to express my sincere gratitude to my supervisor, and teacher during my Pre-masters, Susan McKenny. Without her patience, kindness and great advice I would not have reached this point today. Besides the great help and guidance, her friendly, cheerful and open attitude always gave me a warm and confident feeling during this whole process of graduating. Also, a special thanks to Talitha Visser, who was kindly willing to become my second supervisor when Fer Coenders retired. She provided me with useful feedback and helped me where needed. So, al so many thanks to her and for the effort she took.

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I hope you enjoy reading this thesis.

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1 Introduction

Since the beginning of the 21st century the renewal of chemistry education is an ongoing theme for educational designers and chemistry teachers. The current chemistry curricula don't have a lot of learning materials which let students learn via concepts that emerge from real-life scientific issues, while an adjustment in the current curricula could inspire students (Gilbert, 2006). In contrast with traditional chemistry education, context-based approached education, where chemistry concepts are connected to a context, can contribute to the accessibility of chemistry concepts for students. King, Bellocchi and Ritchie (2008); Stolk et al. (2009) point out that students are more likely to be more engaged in meaningful tasks with real-world connections, making them more actively involved in their learning process. Considering what is mentioned above, the context-based approach seems to be of value for renewal of the chemistry curriculum and its materials since a context provides helps to connect and engage in chemistry education.

Also, the "Comissie Vernieuwing Scheikunde Havo en Vwo" stated that the use of a context during a chemistry curriculum could stimulate the learning via concepts (Driessen & Meinema, 2003).

In previous research done by Gilbert, Bulte and Pilot (2011) results show that context-based learning makes chemistry concepts more accessible for students and active engagement occurs.

Several aspects were considered by designing and evaluating the context-based learning curricula. If a curriculum undergoes a renewal, several aspects should be considered like the anticipation of teachers on the students' learning process, preparations and the execution of the lesson (Ball and Cohen, 1996).

The University of Twente took the challenge to design a chemistry context-based learning curriculum and its lessons that would contribute to the renewal of the chemistry curricula for VWO classes in the Netherlands where the content and concept knowledge of a teacher is considered. The great challenge remains to involve the students during the lessons and activate their learning. How can a context-based learning lesson help student to engage to the chemistry concepts and fulfil their task successfully? And what opportunities should be provided to the students? This research examines what happens with the learning activation and engagement of students during chemistry lessons that use a context-based approach.

1.1 Problem statement

Despite the positive reactions of students on the motivational level and the better understanding regarding the nature of chemistry education, the learning results don't seem to improve after receiving a context-based approach (Bennett, Hogarth, & Lubben, 2003; Bennett & Lubben, 2006). Two possible causes for this could be that the current developed lesson materials don't support teachers enough to transfer the content via the context-based approach and the current chemistry books stayed traditional where contexts that are used are not connected to contemporary content but have a more decorative function instead. In previous research a set of guidelines were developed to help the designers of new chemistry curricula with the renewal and development of the context-based learning (CBL) lessons. These guidelines provide help for the development of the curricula and help to resolve the problems that are abovementioned and help to promote curriculum changes by means of describing how context-based chemistry curriculum materials can help foster the knowledge, skills, and attitudes of teachers and students to promote curriculum reform (Knoef, 2017).

If there is an improvement on outcomes and learning results after a CBL lessons remains unanswered for now since there is not enough evidence so far. Learning activation could be observed during a CBL lesson and through further research the outcomes and the changes on learning perception, learning skills and knowledge that occur or don't. Dorph et al. (2016) state that skills and knowledge should be addressed during a lesson to determine if learning activation occur. An addition to the learning activation is the engagement of students during the chemistry lesson since a good engagement level should work towards better participation and more persistence to complete a task (Campos & Greif, 2003) also engagement works towards a better intrinsic motivation according to Stefanou et al. (2004).

1.2 Context

In the year 2003 the "Commissie Vernieuwing Scheikunde Havo en Vwo" stated that the use of a context during a chemistry curriculum could stimulate the learning via concepts (Driessen & Meinema, 2003). Prior research on a context-based approach of lesson content shows that students find the content more motivational (King, Bellocchi, & Ritchie, 2008) and that they learn more about the nature of sciences

(Çam & Geban, 2011). Despite the efforts made so far, the context-based education approach does not yet lead to better student results in chemistry (Bennet, Hogarth, & Lubben, 2003; Bennett & Lubben, 2006).

The current research that is done is a part of a greater study called "the IMPULS study" which is an initiative of the University of Twente and funded by the Dutch ministry of Education, Culture and Science, and over a period of two years. The aim of the IMPULS study is to co-design a context-based chemistry curriculum for secondary schools. For the designing of the context-based curriculum groups of experts are formed and called Teacher Development Teams (TDT's) and consist of researchers, teachers from secondary schools, students and expert teachers. Together they work towards a context-based chemistry curriculum and its teaching materials that can be carried out in secondary schools. These TDT teams help to develop, articulate and refine the chemistry curricula in a practical and effective way (Boschman, McKenney, Pieter, & Voogt, 2016).

The IMPULS study is spread over multiple years and uses the first year to develop the CBL lessons/curriculum. The next phase is to test and implement the CBL lesson with multiple groups of VWO students in the fourth and fifth grade. After implementation a field study is done to research the students' outcomes and attitudes on CBL. The present research will be an element in the last part of the IMPULS study and combines the field study findings with recommendations and implications for the future.

1.3 Goals of this research

This research examines the learning activation and engagement of students during the chemistry CBL lessons. The goals of this research are to determine if the CBL lessons influence the attitude and perception about chemistry education by measuring the learning activation (through competency beliefs, fascination and values) and the engagement of students and if there exists a connection between learning activation, engagement and opportunities to engage throughout the CBL lessons.

1.4 Preview of this research

This research focusses on the possible impact of learning via a context with the help of the CBL lessons. The conceptual framework will elaborate on the concepts that were used in this research with the help of existing literature that lead to the synthesis of this research and the research questions. Through student questionnaires, learning activation will be examined on the dimensions of Competency beliefs, Fascination and value where the questionnaire serve as a pre and post-test which will be filled in by fourth grade VWO students from which a number of students follow a regular chemistry lesson and serve as a control group, and a number of students that will receive the CBL lesson and serve as the experimental group in this research. Student focus groups will provide more in-depth information regarding learning activation and engagement and classroom observations will present more information on engagement and the opportunity to engage and learn during the chemistry lessons. Findings will be presented in the fourth chapter and the fifth chapter will answer the research questions. The research will be ended with reflection on the findings, limitations of this research and implications for practice and further research for the future.

2 Conceptual framework

In the first part of the IMPULS study, context-based lessons were designed that could be executed by teachers to support and facilitate the learning process of students and work towards a better understanding of the chemistry concepts within the context that was given and thought. The upcoming paragraphs describes the key concepts that are used during this research and examined during the execution of the designed CBL lessons. The synthesis of this research is given and explained with the help of the conceptual model underlying this research after the elaboration of the key concepts. The last paragraph (2.5) focusses on the research questions underlying this research.

2.1 Context-based learning

The Latin language describes the word context as “contexere”, which stands for; weave together, coherence, connection and relationship (Gilbert, 2006). With this said, the effect of the word context seems of a great influence. With the use of a context during a chemistry lesson, a chemistry topic and various concepts can be connected to contemporary scientific matters. Learning through a context can contribute to a coherent structural meaning of new content that clarify chemistry concepts. Mostly the current chemistry curricula are not yet designed to transfer knowledge via a contemporary context such as; scientific articles or research but more in a traditional way via a study book. Gilbert, Bulte and Pilot (2011) point out that there are five major challenges that should be considered by designing a context-based curriculum; a clear purpose, an overload of content, no coherence in learning by students, relevance seems unclear to students and the shortcoming of transferring knowledge to new and other contexts.

The CBL lessons that were used and executed during this research were developed by the Teacher Development Teams of the IMPULS study. The abovementioned major challenges were considered during the development and research phase of the CBL lessons by the TDT and the three criteria that were stated by the TDT during the designing were, a) facilitate the learning process of students b) supporting teachers in preparations of their lessons and c) the support of teachers during the lessons. De development and the design led to CBL lessons which contexts evolve around *“the early detection of cancer though blood”* and *“fuel through solar”* and were carried out during this research.

2.2 Learning activation

The Science Learning Activation Lab in California desired to generate a conceptual framework to organize the investigation and design of experiences that would initiate persistent engagement in science learning and inquiry. Toward this end, a new construct was hypothesized, learning activation, which can be defined as a combination of dispositions, practices, and knowledge that enables success in science learning activities. Based on the belief that developing and supporting the science learning activation of young learners should be the foundation for science learning opportunities across settings, an instrument designed to measure activation than was developed by the Science Learning Activation Lab in California. To measure the learning activation of students three dimensions were established; Competency beliefs (2.2.1), Fascination (2.2.2) and Values (2.2.3) The instruments that are designed to measure these dimensions, and thus the learning activation, would be used to evaluate the impact of science programs and experiences (Moore, Bathgate, Chung and Cannady, 2011). For the IMPULS study and this research these instruments, adapted from the Science Learning Activation Lab in California (2016), are used to examine the learning activation during the CBL lessons. Each dimension will be further explained in the upcoming paragraphs and will elaborate on its use, its importance and utilization.

2.2.1 Competency beliefs

The dimension 'Competency beliefs' is defined as the individual judgement of the own capabilities to organize or execute courses or performances (Bandura,1986). Schunk, Pintrich, and Meece (2008) state that competency beliefs or self-efficacy beliefs are a relevant predictor of several types of achievement behavior e.g. engagement. In this research competency belief is one of the dimensions that predicts the learning activation of students and as mentioned before, the learning activation of students is important to define the impact of science programs and experiences (Moore, Bathgate, Chung and Cannady, 2011) and in this research the competency beliefs dimension helps the gain insight on the impact that the CBL lessons have on this dimension and thus the learning activation during the chemistry education.

2.2.2 Fascination

The second dimension that will be measured during the CBL lessons is 'Fascination' which is explained as emotional and cognitive attachment or obsession with chemistry topics and tasks. Accordingly, this dimension includes aspects of what many researchers have referred to as curiosity (Harty and Beally, 1984; Gardner, 1987; Loewnstein, 1994; Litman and Spielberger, 2003). As decribed by Dorph, Cannady and Schunn (2016) chemistry topics can have an emotional and cognitive fascination for students and its tasks can serve as an intrinsic motivation during participation. Moore, Bathgate, Chung and Cannady (2011) state that fascination also includes affective elements such as emotions related to science, scientific inquiry, and knowledge. Research to date in each of these areas suggests that these constructs may be compelling motivators to engagement, persistence, and attainment in, as well as choice towards, science learning (Bathgate, Schunn and Correnti, 2014). By investigating the fascination of students during the CBL lessons, more information will be obtained on the levels of their motivation to engagement, persistence, and attainment in, as well as choice towards science learning.

2.2.3 Values

Values will be measured last to investigate the learning activation among the students. Eccles and Wigfield (2002); Osborne, Simon and Collins (2003) explain values as the importance placed on knowing and being able to do chemistry because of its utility in meeting personal goals such as fixing a problem at home or its utility to society, solving environmental problems for example. Understanding of different interactions that can occur with science and/or chemistry knowledge and skills, places a value on those interactions. Also, when chemistry is valued in the role it can play in a student's own life and in society it is more likely for students to engage in chemistry learning (Eccles, 2005; Lyons, 2006). Hill and Tyson (2009) consider four ways in which students value chemistry value. First; the knowledge that is learned, second; ways of reasoning during chemistry, thirdly; role of chemistry in family and society/community context, and fourth; others' perceptions on chemistry. The importance of valuing chemistry, according to Moore, Bathgate, Chung and Cannady (2011) is that: "Learners who value chemistry are expected to be more likely to identify it as a possible career as they believe it is worthwhile and a valuable pursuit. Those who value science and the role it plays both in their own live and in society are more likely to engage in learning science in and out of school whether or not they find it fascinating." In the light of the IMPULS study and this research also the Value dimension is of importance to determine if the developed CBL lesson materials contribute to this dimension since its impact seems a predictor for the engagement of students during chemistry education.

2.3 Engagement

Besides the learning activation, engagement is also an important factor in chemistry education and is described as focus participation and persistence on the task. Engagement knows multiple dimensions; affective, behavioral and cognitive engagement. The definition of engagement according to Jimerson, Campos and Greif (2003) are the feelings of a student about peers, school and teachers (e.g., positive feelings towards students or teachers) in the affective dimension, the behavioral dimension are observable actions or performance like extracurricular activities, such as sports, fulfilment of homework, and grades/scores on achievement tests. The last dimension that is described is the cognitive engagement that includes students' perceptions and beliefs that can be related to themselves, peers, teachers and schools (e.g., self-efficacy, motivation, perceiving that teachers or peers care, aspirations and expectations). Further investigational research of the multidimensionality of engagement showed that an addition could be assigned to the abovementioned definitions these are as follows: affective engagement focuses on whether the emotions that occur as part of completing a task are positive and high arousal rather than negative and low arousal; behavioral engagement focuses on whether learner behaviors are related to completing the task or are off task; and cognitive engagement focuses on whether thought processes and learner attention are directed towards meaningful processing of information involved in completing the task (Ben-Eliyahu, Moore, Dorph & Shunn, 2016).

The different above-mentioned engagement dimensions can be measured through a set of behaviors and/or emotions that occur during a chemistry activity. These different dimensions will be described and displayed in the upcoming paragraphs. The measuring construct that was used during this research is an observation instrument designed by Activation lab (2016).

2.3.1 Affective engagement

The level of affective engagement can be identified through levels of arousal that range from positive aroused till negative aroused. These levels can be assigned to an individual or group of students during chemistry education by observing and assigning underlying emotions that occur. The following table shows which levels of arousal can be distinguished and represents the emotions that match the different levels of arousal.

Table 1. Indicators of affective engagement

Level of arousal	**Emotions that occur**
Positive aroused	amazed, joyful, fun, happy, enthusiastic, eager, inspired, determined, startled-positive
Positive unaroused	alert, calm, relaxed, at ease
Negative unaroused- flat / mixed	bored
Negative unaroused	sad, drowsy, tired
Negative aroused	distressed, upset, angry, frustrated, worried, startled-negative

Note: adapted from original measurement construct "the engagement observation protocol" (Activation lab, 2016).

2.3.2 Behavioral engagement

During a chemistry activity behavioral engagement can be measured by four types of participation that range from active till disruptive, each of them have multiple behavioral actions and/or emotions that can be identified during an activity and represents the participation behavior. In the table below the indicators of behavioral engagement are represented.

Table 2. Indicators of behavioral engagement

Type of participation	**Participation behavior**
Active	active, takes initiative, eager to participate. (e.g., hand raising, asking and answering questions are ok to code as active in a setting without physical opportunity)

Passive +	ready to learn and participates
Passive -	doesn't take initiative, gives up, unprepared, or distracted
Disruptive	actions interfere with self and other's learning

Note: adapted from original measurement construct "the engagement observation protocol" (Activation lab, 2016).

2.3.3 Cognitive engagement

The third element of identifying engagement is the cognitive engagement of students. The concepts that can be measured vary from high-order thinking till unknown thinking during chemistry education. By identifying different elements of once involvement with cognitive processes the right concept can be assigned during the observation. The table illustrates the above-mentioned items and how it measures the cognitive engagement.

Table 3. Indicators of cognitive engagement

Cognitive process	**Involvement with cognitive process**
High-Order thinking	going beyond the basics (e.g., predicting, connecting, problem-solving, claim making, noticing similarities/ differences, metacognition)
Required thinking	doing the basics (e.g., attentive, focused on task, reciting, naming, identifying, discussing procedures, complete worksheet as directed)
Unrelated thinking	uninvolved with the task
Unknown thinking	unknown processes

Note: adapted from original measurement construct "the engagement observation protocol" (Activation lab, 2016).

2.4 Opportunity to engage and learn

To change or improve chemistry education, multiple elements should be addressed. Learning activation and the different types of engagement are explained in the above-mentioned paragraphs and illustrate the importance and their impact on chemistry education. Another key element to add is the opportunity to engage and learn for students during chemistry education and/or activities and will be further illustrated in the upcoming paragraph. In addition to the engagement observation instrument, another observation instrument is adapted from Activation lab (2016) to detect different practical elements that contribute to the classroom and lesson setting and thus creates an opportunity to engage and learn for students. The learning environment and the facilities that are given helps student to engage during the lesson (Stefanou, Perencevich, DiCintio and Turner, 2004).

To measure the opportunity to engage and learn for students, a set of four dimensions with practical adjectives each can be detected in a classroom setting. Besides cognitive, behavioral and affective engagement that occurs during a chemistry lesson the dimension of; space, activity structure, social and material aspect should be considered since these elements can contribute to the students' engagement in the learning environment. The teacher should contribute to work toward a learning environment where students be motivated to engage and learn during the chemistry lesson. These opportunities can be arranged by the teacher prior to the lesson (e.g. location, material choice, involvement of facilitator etc.) in addition choices that can be made by students should be considered as well to work towards a feeling of autonomy by students. Students that can make their own choices during an activity can experience a level of autonomy which can enhance the intrinsic motivation of students (Patall, Cooper & Robinson (2008)) according to Williams (2008) choices should be meaningful to enhance the intrinsic motivation of a student. Suggested by Stefanou, Perencevich, DiCintio and Turner (2004) the beforementioned level of autonomy can be supported on three levels; organizational (e.g., allowing students to choose the seating arrangement or participate in setting classroom rules), procedural (e.g., offering students choices about materials to use in classroom tasks or how competence will be demonstrated) and cognitive (e.g., allowing students to generate their own solutions to a problem or evaluate various solutions). In the following four paragraphs each abovementioned dimension; Space (2.4.1), Activity structure (2.4.2), Social (2.4.3) and Materials (2.4.4) will be explained further.

2.4.1 Space

To identify the space and its opportunities the following question could be asked to determine if the space, where the chemistry lesson or activity is provided, meet the requirement of opportunity to engage and learn for students "*do students have choice in how and where they interact with the space? Can they sit or stand, move around etc.?".* The following adjectives could be observed/identified to illustrate the space where opportunity to engage and learn occur; *location*- school, museum, outside, community center, library, lab, home and *type*- classroom, exhibit, afterschool program, camp, class, lecture, assembly.

2.4.2 Activity structure

During the chemistry lesson the structure of the activity and its content can be analyzed by the upcoming elements. A question that could be a good starting point for the activity could be "*what choices (if any) are participants able to make about the activity?"* this could help the facilitator to think of a suitable structure for the activity. The following adjectives could be observed/identified to illustrate the structure of the activity that is utilized; *idea*- prominent, powerful, central to science/chemistry; *activity*- facilitate, presentation/demonstration, hands on or tinkering, interactive exhibit, observational exhibit, didactic; *interaction*- competitive, cooperative, independent; *procedure*- fixed, open; *outcome*- fixed result, open result.

2.4.3 Social

Since learning in a classroom mostly occurs with the help or participation from a facilitator or peers the social aspect during a lesson and how social occurs should be considered prior, during and afterwards a chemistry lesson/activity. The question that could be asked in this dimension is*" do students have the choice in how and whom they interact?".* The following adjectives could be observed/identified to determine how the social aspect of the activity is set up; *outline of interaction style*- interactive participant, lecture, demonstration with materials, reference only (information, answer giver), non-interactive; *facilitator involvement*- highly involved, not involved.

2.4.4 Materials

The last dimension which demonstrates the classroom/activity opportunities are materials that could be utilized. Questions that can help at the start or with the preparations of the lesson/activity are: "*are materials organized and easily accessible?"* and *"do students have choice in materials"*. The following adjectives could be observed/identified to illustrate the organization and accessibility of the materials; *quality*- organized, labelled, well-maintained; *availability*- available, offered, allocated, shared; *sufficient*- infinite, adequate, insufficient for group; *range*- vast variety, minimal, single resource; *authenticity to science*- authentic/real, models/mimics, not authentic/not representative; *adequacy of scaffolding*- models, diagrams, pictures, examples, prompts, labelled, signage, n/a.

2.5 Synthesis

Figure 1 demonstrates the underlying conceptual model that was used during this research. Throughout the research the possible dimensions of learning activation (e.g.: competency beliefs, fascinations and values) are studied and its possible relation with the engagement of students during the CBL lessons. This also is studied the other way around to see if and what levels of engagement (e.g.: affective, behavioral and cognitive) influence the learning activation. The opportunities to engage and learn are studied in a broader sense to see which aspects (e.g.: space, activity structure, social and material) are represented during the CBL lesson. At the start of this study the displayed conceptual model assumes that the direction of relation between the key aspects of this study will go as illustrated, but possible relations and/ or connections that occur during this study are further examined and described.

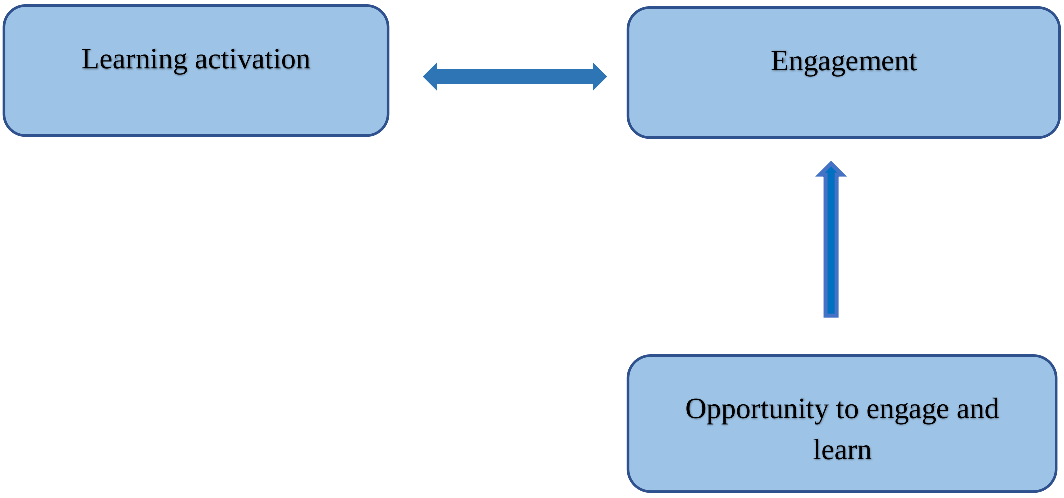


Figure 1. Conceptual model underlying this study

2.6 Research questions

To anticipate on the learning process of the students, the CBL lessons were implemented in the current chemistry curricula of several Dutch VWO classes. This research aims for an answer regarding what happens with the learning activation and engagement of students during the CBL lessons. The research questions that examines this, focus on whether CBL lessons have an impact on students' perception regarding competency beliefs, fascination and values (learning activation) in chemistry education, the different levels of engagement (affective, behavioral and cognitive) and the opportunity to engage and learn.

The research will attend to answer the following research questions:

RQ 1: What characterizes learning activation in CBL and regular chemistry lessons?

RQ 2: What levels of engagement are observed during the CBL lessons?

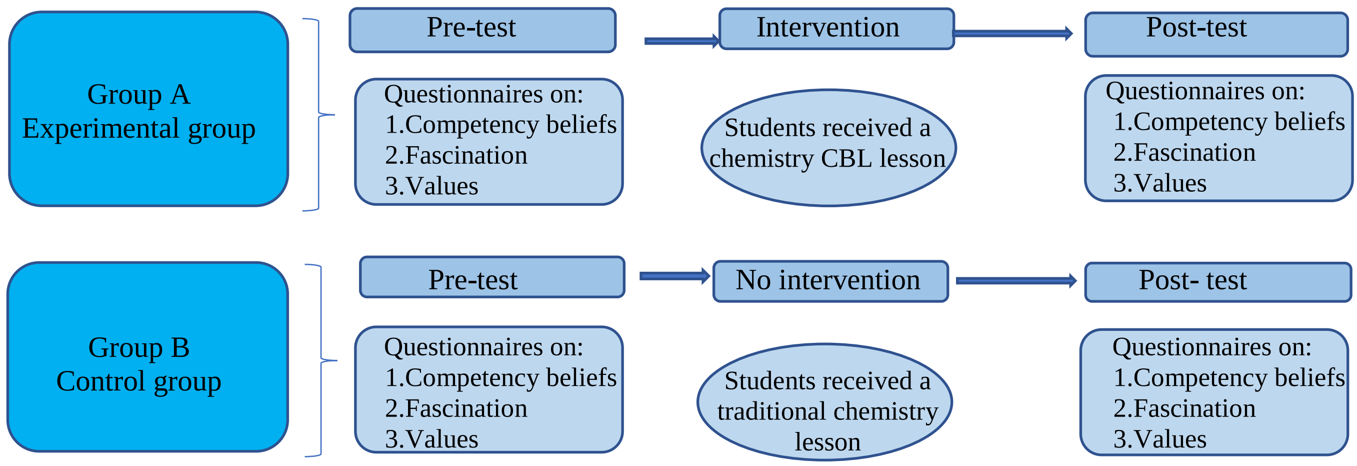
RQ 3: What opportunities to engage and learn are observed in the CBL lessons?

RQ 4: In the CBL lessons, what relationships appear between learning activation, engagement, and opportunities to engage and learn?

3 Research method

3.1 Research design and model

The research is based on mixed-methods where a quasi-experimental control group design was applied to capture quantitative data by using questionnaires that provide insight in learning activation. The questionnaires functioned as a pre-test at the start of the chemistry lessons and as a post-test directly after the chemistry lessons. The specific design was a *pre-test - post-test group design* which is displayed in the following figure:



Key: CBL= Context -based learning

Figure 2. Quasi-experimental control group design

The qualitative data that was gathered had a more descriptive nature which collected data via focus-group interviews, a teacher interview, classroom observation and (video) observations which gathered information regarding to the engagement and opportunity to engage during a chemistry lesson. The following research model illustrates the different data sources that were used and their measuring goals.

Data source ▼ | Measuring ▶	RQ 1	RQ 2	RQ 3	RQ 4
Student Questionnaire (pre-/post-test)	**X**			
Student focus group	**X**	**X**		**X**
Classroom observation		**X**	**X**	**X**
Teacher interview		**X**		

Figure 3. Research model

3.2 Respondents

The research is carried out in a middle-sized town in the easternmost province of the Netherlands where a total of three, fourth grade VWO classes of a secondary school participated and were given the three questionnaires (Competency beliefs, Fascination and values) at the start of the chemistry lesson and the same three questionnaires were taken directly after the chemistry lesson. A total of 65 students participated from which 23 students (Group A, experimental group) received the CBL lesson of their own chemistry teacher who was involved in the IMPULS study and the development of the CBL lessons and materials. The other 42 students (Group B, control group), divided over their two regular VWO classes, received a traditional chemistry lesson of their own teacher who was not involved in the IMPULS study. The participation was fixed since the students followed their regular school schedule. To collect additional data on the CBL lessons, two, fifth grade VWO classes (Group A, experimental group) from a secondary school that came from another small sized town in the easternmost part of the Netherlands were invited to participate in the CBL lessons at the University of Twente. This chemistry CBL lesson replaced their traditional chemistry lesson and their regular teacher and their participation was fixed. The lesson was given by the experienced chemistry teacher and a guest speaker who were involved in the IMPULS study and the development of the CBL lessons and materials. The two VWO classes that participated at the University in this research had a total of 51 students, divides over two classes that were their regular chemistry classes, and were given three questionnaires (Competency beliefs, Fascination and values) at the start of the CBL lesson and directly after the lesson they received the same three questionnaires.

At the end of the CBL lessons, student focus-groups were formed with 4 students each. Even though the sampling was random and based on voluntary attendance, the distribution of gender was fifty-fifty in all the student focus-groups.

An experienced chemistry teacher that provided the CBL lessons to the experimental group (Group A) and was involved in the IMPULS study was approached for an interview regarding his approach of teaching chemistry in a context, his ideas on engagement, opportunity to engage and learn and learning activation. The distribution of respondents is illustrated in table 4.

Table 4. *Descriptive statistics for respondents*

	Student questionnaires	Student focus group	Teacher interview
Students	(N=116) %	(N=12) %	
Grade and level			
4 VWO	56	34	-
5 VWO	44	66	-
Group A (Experimental group)	63	100	-
Group B (Control group)	37	0	-
Teachers			(N=2) %
Group A	-	-	50
Group B	-	-	50
Years of teaching experience			
>15 years	-	-	50
>15 years	-	-	50
Gender			
Male	-	-	50
Female	-	-	50

3.3 Instrumentation

A variety of instruments were used to collect data to answer the research questions. For the quantitative data, to examine the learning activation three questionnaires were used on; Competency beliefs, Fascination and Values regarding chemistry which were taken at the start (pre-test) of the chemistry lessons and directly after (post-test) the chemistry lessons. So, each student received two times, three questionnaires. The qualitative data collection consisted of three student focus-groups with fourth grade VWO students that experienced a context-based learning lesson furthermore observations were done with the use of IRIS Connect video registration and a real-life observation to gain insight in the engagement of students during the lessons on individual and group level also the learning environment was observed in order to examine the opportunity to engage during the chemistry lessons. The last instrument that was used was an interview with the experienced teacher. The following instrument matrix shows which instruments were used to measure the constructs of this research.

Table 5. *Instruments matrix*

	Student questionnaire	Student focus group	(Video) observation	Teacher interview
Learning activation	**X**	**X**	—	—
Engagement	—	—	**X**	**X**
Opportunity to engage	—	**X**	**X**	**X**

3.3.1 Student questionnaires

The first concept that was measured, was the learning activation of students during chemistry lessons. The dimensions of this concept; competency beliefs, fascination and values were each separately measured with a questionnaire which was adapted from the Activation lab (2016) and was translated from English to the Dutch language (Appendix A, B and C). The questionnaires were filled in by the students at the start of the chemistry lesson as the pre-test and directly after the chemistry lesson as the post-test. The original questionnaires scored high on their reliability that is measured by Cronbach's Alfa (α) and thus it was important that the translated versions of the questionnaires would also retain the high reliability to be a valid instrument to use and measure the construct. Each questionnaire; Competency beliefs, (3.3.1.1), Fascination (3.3.1.2) and Values (3.3.1.3) will be further explained in the upcoming paragraphs, and the original reliability and the reliability of the translated questionnaire will be presented.

3.3.1.1 Competency beliefs

The original competency beliefs questionnaire (Activation lab,2016) scored a reliability of $\alpha = .83$, the translated version scored a reliability of $\alpha = .74$. Even though the reliability score was lower than the original questionnaire, it was satisfactory enough and acceptable to use it to measure the competency beliefs dimension since it scored >0.7 on Cronbach's alpha. The number of items was eight in the questionnaire and were scored on a 4-point Likert scale ranging from (1) "always" to (4) "never" or (1) "yes!" to (4) "no!". The questionnaire includes questions like "I can do the chemistry activities I get in class" and "I think I am very good at: Coming up with questions about chemistry". The questions that were asked had an individual character and collected information regarding the learner's beliefs about their ability and competence to participate in chemistry learning education.

3.3.1.2 Fascination

The original fascination questionnaire (Activation lab,2016) scored a reliability of $\alpha = .86$, the translated version scored a reliability of $\alpha = .88$ and was satisfactory and good to use for measuring the fascination dimension since it scored > 0.8 on Cronbach's alpha. The number of items in the questionnaire was eight and were scored on a 4-point Likert scale ranging from (1) "every day" to (4) "never" or (1) "yes!" to (4) "no!". The questionnaire includes questions like "I wonder about how chemistry works" and "I want to know everything about chemistry". The questions that were asked had an individual character and collected information regarding the learner's interest and fascination towards chemistry learning education.

3.3.1.3 Values

The original Values questionnaire (Activation lab,2016) scored a reliability of α = .83, the translated version scored a reliability of α = .83 which was satisfactory and good to use to measure the values dimension since it scored > 0.8 on Cronbach's alpha. The number of items was eight in the questionnaire and were scored on a 4-point Likert scale ranging from (1) "all the time" to (4) "never" or (1) "yes!" to (4) "no!". The questionnaire includes questions like "Knowing chemistry helps me understand how the world works" and "I think chemistry ideas are valuable ". The questions that were asked had an individual character and collected information regarding the learner's ability to value chemistry with its utility in meeting personal goals and its utility to society.

3.3.2 Student focus group

During the student focus group discussions students were asked to explain and tell more about their experience with the chemistry course in general and the received CBL lessons the nature of the discussion was semi-structured since the main goal was to gather more specific information about various elements. The first topic that was questioned were the three elements; competency beliefs, values and fascination, that were questioned in the questionnaire. Questions such as *"What do you think of chemistry?"* or *"Do you think chemistry is important?"*, gave more insight in these elements.

A second aspect of the student focus group discussion was to get more specific information regarding the needs of the students during the chemistry lessons and the opportunity to engage that they have experienced during the CBL lesson. This was discussed by asking questions like *"What do you think of the presented materials?"* or *"Which sort of activity do you prefer during the lesson?"*.

3.3.3 Classroom observation

The observations were done by real life observation during the CBL intervention and through video observation (IRIS Connect). An observation tool was used to measure the frequency of the three dimensions of engagement during the chemistry lesson; cognitive, behavioral and affective. The observation tool was adapted from Activation lab (2016) and the dimensions were scored with a code ranging from (1) “not observed (0%)” to (4) “A lot to most (>50%)”. The observation tool is presented in Appendix D.

3.3.4 Identifying opportunities to learn and engage

Using the observation instrument/ checklist adapted form Activation lab (2016) more insight was gained of the space an activity structure and its opportunities for the students to engage and learn during the CBL lessons. The observation took place during the CBL lessons and the checklist covers; materials, activity structure, social and materials. Each element covers a set of dimensions which helps to give a fair representation of the conditions were the students received their lesson. By determining adjectives like *“availability of materials”* and *“sort of interaction during the activity”* and their applicability to the situation, a representation of opportunity to engage was made.

3.3.5 Teacher interview

An experienced chemistry teacher was interviewed to gain more in-depth information about his perception about the CBL lessons that were given. His involvement in the IMPULS study gave more in depth information about the CBL procedure which was experiences by himself as a teacher and by transferring the content to the students. Also, his perception on the possible effects of a CBL lesson were discussed. The nature of the interview was semi-structured which means that no fixed questions were asked but the concepts of chapter two were discussed. A concept that was discussed was “engagement of students during a CBL lesson and how to reinforce it” and “the preconditions to give a (good) CBL lesson”. Also, the role of himself as a teacher and the role of students to make the CBL lessons work were discussed in the teacher interview.

3.4 Procedure and data analysis

3.4.1 Qualitative data

The student focus-groups were formed on the day of the received CBL lesson and took place 15 minutes after their lesson. The location stayed the same for the students, but a different room was arranged for the group discussion. All the focus group discussion took approximal 35-45 minutes. The last part of the discussion was free for the students to discuss the CBL lesson that they have experienced and elaborate more on their opinion regarding this type of chemistry lesson that revolves around a context there also was an opportunity to make implications for improving that will be further discussed in the last chapter. The information that was gathered during the discussion formed back ground information for this research and will be discussed further in the findings chapter and conclusion and discussion chapter.

The *classroom observations* took place during the CBL lessons and an observation tool was filled in during each of the three-hour during lessons. In total three complete CBL lessons, of three hours each, where attended by the researcher and used for the observations. There was a break of 15 minutes during each lesson. The researcher introduced herself at the start of each lesson but did not participate in the chemistry activities during the lessons. In addition to the real-time observations, video recordings were taken, with the help of IRIS Connect, of the three CBL lessons and were analyzed and coded by the researcher and an independent researcher. Both used the observation tool/checklist to score observed or not observed forms of engagement. The coding was done with the help of an observation tool (Activation lab, 2016) and the dimensions of engagement (cognitive, behavioral and affective) were scored with a code ranging from (1) “not observed (0%)” , (2) ”rarely” (<25%), “some”(25-50%) to (4) “A lot to most (>50%)”. The analysis of the observation tool was done with the help of IBM SPSS and the deductive coding of the tool was analyzed with Cohen’s kappa which indicated an inter-rater reliability of 0.77 which can be interpreted as moderate since the kappa value of the observations lies between .60 and.79. This inter-rater reliability score indicated that the observation outcomes between the raters gave consistent estimates of the same behavior and were substantial on the level of agreement.

The teacher interview took place at the University of Twente after the CBL lesson was given by the experienced teacher. The interview itself took place in the office of the teacher at the University of Twente and had a duration of proximate 45 minutes. The gathered information was used as back ground information since the teacher was partially biased in his opinion considering his interest in the IMPULS study and his involvement of teaching the CBL lessons.

3.4.2 Quantitative data

Questionnaires were carried out at the start of the chemistry lessons and directly at the end of the lessons after a brief introduction and explanation about how to fill-in the questionnaire. Both groups, the experimental group (A) and control group (B), received three identical questionnaires on; competency beliefs, fascination and values at the beginning and at the end of the chemistry lesson. The participation on the questionnaires for both groups was fixed and for the students of the experience chemistry teacher, that carried out the CBL lessons, the attendance in the CBL lesson replaced their regular chemistry lesson. The classes that did received the intervention (CBL lesson) were told at the start of their chemistry lesson that the execution of the lesson was somewhat different than what they were used to since their lesson would not be a traditional chemistry lesson with the regular method but a chemistry lesson that made use of a different context (early detection of cancer through blood) and different materials (e.g. articles, video demonstrations, guest speaker).

The choice was made to distribute questionnaires on paper, so that a quick check could be done by the researcher to prevent missing data (e.g.: half-filled in questionnaires, double checked boxed and missing pages) and a correct set before and after, so that these could be paired as samples for the statistical measurement. Data that was gathered from the questionnaires was analyzed by IBM SPSS and a paired sample T-test done to determine if there was a significant difference between the pre- and post-test filled in questionnaires. To see if there was a statistically significant difference between means of the experimental- and control group a one-way analysis of variance was conducted.

4 Findings

4.1 Learning activation

The aim of the upcoming findings is to answer the research question: *"What characterizes learning activation in CBL and regular chemistry lessons?"* During the research two groups were studied and compared before and after the (CBL) chemistry lesson. The experimental group, group A, received an intervention (the CBL lesson) the comparison group, group B received a traditional chemistry lesson which is carried out with the help of the existing chemistry lesson method and its lesson book "Nova" (uitgeverij Malmberg, 2015). The structure of the traditional lesson is more teacher centred and the outcomes are fixed whereas the CBL lessons are more student centred and create more opportunities for students' own input an outcome during the lesson. Findings on the learning activation thus competency beliefs, fascination and values will be explained with the help of statistics.

4.1.1 Competency beliefs

Students' beliefs on being competent during a chemistry task and their own view on competency was researched with the help of a questionnaire. Group A showed no big shifts in mean scores after comparing the before and after intervention questionnaires. The only outlier was question three that showed a higher mean (mean=3.12) before the CBL lesson than the mean afterwards (mean=2.83). The mean shows that the students don't think that they can understand all chemistry websites information as good as they thought they would be, looking at the prior filled in questionnaire. What also can be said is that 50% of the mean scores decreased after the CBL lesson on the students' competency beliefs.

A paired sample t-test revealed significant difference ($t(69) = 4.04$, $p = .000$) on the before and after score on the third item of the questionnaire. The other questionnaire items on competency beliefs scored higher on the significance level ($p = > .05$) thus the assumption that there is a statistically significant difference between the before and after filled in the questionnaires cannot be made.

Group B, in comparison with group A, also did not show big differences in mean scores at the before and after filled in questionnaires. The second item on the questionnaire showed a decrease of mean score of 0.25 on competency beliefs and could indicate that students after following a traditional chemistry lesson are less confident than before on the understanding of what is shown in a science museum. An increase was found on the eight item which indicates that students are more confident on their own "doing experiments skills". The mean score illustrates an increase of the mean of 0.18. A paired sample t-test revealed significant difference (t (36) = 2.74, p = .009) on the before and after score on the second item of the questionnaire. The other questionnaire items on competency beliefs scored higher on the significance level (p = >.05) thus the assumption that there is a statistically significant difference between the before and after filled in questionnaires cannot be made.

Between groups

To detect if there was a statistically significant difference between the experimental- and control group a one-way ANOVA was executed on the pre-test and the post-test. The first questionnaire revealed on the first item *"I can do the chemistry activities I get in class"* a significant difference between the groups *F* (1,114) = 4.592; p = 0.034. The second questionnaire revealed a statistically significant difference between the experimental group and comparison group on item 1: *"I can do the science activities I get in class" F* (1,107 = 6.210 ; p = 0.014) and item 6 *"I think I am very good at: Figuring out how to fix a science activity that didn't work" F* (1,107) = 5.971 ; p = 0.016. The other questionnaire items on competency beliefs scored higher on the significance level (p = > .05) thus the assumption that there is a statistically significant difference between the experimental- and control group cannot be made.

Table 6. Pre- and post-test data on competency beliefs between groups

	Group A				Group B			
	Before intervention		After intervention		Before chemistry lesson		After chemistry lesson	
variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
CB 01	2.93	0.53	2.85	5.53	3.17	0.62	3.11	0.51
CB 02	2.36	0.59	2.38	0.62	2.51	0.55	2.26	0.45
CB 03	3.12	0.50	2.83	0.65	3.00	0.50	2.92	0.59
CB 04	1.96	0.75	1.92	0.67	2.02	0.84	1.89	0.76
CB 05	2.15	0.66	2.13	0.58	2.10	0.54	2.11	0.61
CB 06	2.42	0.62	2.44	0.58	2.57	0.63	2.71	0.52
CB 07	2.38	0.59	2.42	0.58	2.48	0.71	2.50	0.73
CB 08	2.96	0.51	2.97	0.53	2.90	0.58	3.08	0.54

4.1.2 Fascination

Students' fascination on chemistry and chemistry tasks were researched with the help of a questionnaire. Group A showed no big shifts in mean scores after comparing the before and after intervention questionnaires. Though two items did increase on their mean scores that were interesting. The first item "*I wonder how chemistry works"* showed an increase of the mean of 0.19 after the CBL lesson. This increase indicates a growth in fascination on how chemistry works. The fifth item *"I need to know how objects work"* showed before the intervention (mean = 3.07) and after the intervention (mean = 3.86) which implicates that students' fascination on need to know is increased after receiving the CBL lesson which is an interesting finding which will be further discussed in chapter five. What also can be said is that 25% of the mean scores decreased after the CBL lesson on the students' fascination.

A paired sample t-test showed that none of the eight items of the first questionnaire and second questionnaire on fascination scored higher on the significance level ($p = > .05$) thus the assumption that there is a statistically significant difference in mean scores on fascination between the before and after filled in questionnaires cannot be made.

Group B, in comparison with group A, showed a decrease of 75% on the before and after mean scores. Only the third item increased with 0.03 and the fifth item increased with 0.06. Group A showed a greater increase on the fifth item a thus is an interesting finding on the level of need to know of students. Item 1 showed on the before questionnaire *"I wonder how chemistry works"* a higher mean (mean = 2.74) than the after questionnaire (mean = 2.57). A greater difference was discovered on the fourth item with a decrease in mean of 0.21 which indicates that students from the B group don't look for more information after an interesting chemistry activity.

A paired sample t-test revealed significant difference ($t(36) = 2.23$, $p = .032$) on the before and after score on the second item of the questionnaire. The fourth item about looking up information after a chemistry activity also revealed a significant difference ($t(34) = 2.23$, $p = 0.033$) between the before and after questionnaires. The other questionnaire items on fascination higher on the significance level ($p = > .05$) thus the assumption that there is a statistically significant difference between the before and after filled in questionnaires cannot be made.

Between groups

To detect if there was a statistically significant difference between the experimental- and control group a one-way ANOVA was executed on the pre-test and the post-test. The first questionnaire revealed on the first item *"I wonder how chemistry works"* a significant difference between the groups $F(1,114) = 7.732$; $p = 0.006$. The second questionnaire revealed that none of the eight items showed a statistically significant difference ($p = >.05$) thus the assumption that there is a between the experimental- and control group cannot be made.

Table 7. Pre- and post-test data on fascination between groups

	Group A				Group B			
	Before intervention		After intervention		Before chemistry lesson		After chemistry lesson	
variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
F 01	2.78	0.69	2.97	0.53	2.74	0.73	2.57	0.69
F 02	2.74	0.60	2.68	0.63	3.02	0.35	2.86	0.35
F 03	2.82	0.61	2.86	0.52	3.00	0.38	3.03	0.38
F 04	2.01	0.65	2.11	0.60	2.12	0.45	1.91	0.51
F 05	3.07	0.63	3.86	0.65	2.86	0.78	2.92	0.69
F 06	1.93	0.56	1.96	0.55	2.01	0.62	1.92	0.50
F 07	2.24	0.66	2.18	0.66	2.31	0.52	2.25	0.50
F 08	2.16	0.70	2.17	0.59	2.38	0.54	2.22	0.64

4.1.3 Values

Students' values on chemistry and chemistry values to and in society were researched with the help of a questionnaire. Group A showed an increasement on the seventh item of 0.14 which indicated that students find that *"knowing chemistry to be a good citizen"* more important after the CBL lesson than they did before. The sixth item, *"Chemistry makes the world a better place to live"* showed a striking increasement on the means. The first questionnaire scored lower (mean = 1.89) than the second questionnaire (mean = 2.87) and a difference of 0.98 revealed itself after the CBL lesson. The third item showed a slight increase in mean (0.05) which shows that students find *"Thinking like a chemist helpful for other classes".* Two items in total increased on their means (25%) while the other 75% scores lower on the mean scores after receiving the CBL lesson.

A paired sample t-test revealed that there was a significant difference on the seventh item ($t(70) = -2.02$, $p = .047$) the remaining items showed a higher significance level ($p = > .05$) thus the assumption that there is a statistically significant difference in mean scores on values between the before and after filled in questionnaires cannot be made.

Group B showed lower scores on the first and seventh item after the chemistry lesson that they received. The first item *"Knowing chemistry is important for:"* demonstrated a mean on the first questionnaire (mean = 2.64) that was 0.17 higher than after the chemistry lesson (mean = 2.47) that they received. The seventh item showed 0.23 decrease of the means on the *"Knowing chemistry is important for being a good citizen"* which was the most notable difference of the eight questionnaire items. An increase of 0.10 was found on the eight item which tells that students' conceptions about the value of chemistry ideas did changed after their chemistry lesson.

A paired sample t-test revealed that none of the eight items revealed a significant difference ($p = > .05$) on the perception on chemistry values between the first and second questionnaire.

Between groups

To detect if there was a statistically significant difference between the experimental- and control group a one-way ANOVA was executed on the pre-test and the post-test. The first questionnaire revealed on the first item *"Knowing chemistry is important to:"* a significant difference between the groups $F(1,114) = 4.362$; $p = 0.039$. and the sixth item *"Chemistry makes the world a better place to live"* revealed a significant difference of $F(1,114) = 8.715$; $p = 0.004$. The second questionnaire revealed that the sixth item *"Chemistry makes the world a better place to live"* was significant different between the groups F (1,107 = 8.819; $p = 0.004$) the other items showed no statistically significant difference on chemistry values ($p = >.05$) thus the assumption that there is a between the experimental- and control group cannot be made.

Table 8. Pre- and post-test data on values between groups

	Group A				Group B			
	Before intervention		After intervention		Before chemistry lesson		After chemistry lesson	
variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
V 01	2.41	0.62	2.39	0.60	2.64	0.53	2.47	0.56
V 02	2.55	0.78	2.45	0.58	2.74	0.73	2.66	0.71
V 03	2.09	0.50	2.14	0.49	2.29	0.55	2.34	0.53
V 04	1.96	0.67	1.96	0.64	2.07	0.34	2.03	0.68
V 05	1.91	0.53	1.87	0.61	1.90	0.58	1.82	0.46
V 06	1.89	0.61	2.87	0.72	2.55	0.59	2.45	0.69
V 07	2.01	0.63	2.15	0.67	2.26	0.63	2.03	0.72
V 08	3.18	0.53	3.10	0.54	2.98	0.47	3.08	0.43

4.1.4 Student focus-group

The student focus-group discussions led to more in-depth findings regarding the learning activation. The students from the student focus-groups all received a CBL lesson and showed similarities between the groups regarding to the different elements of learning activation. On the level of competency beliefs, students agreed on the difficulty of the “new materials” and the articles. They felt confused about their own competence and at the start of the assignment. Though after the first half of the CBL lesson, students felt more confident in their own abilities and were more eager to ask questions in order to finish the assignment. On the level of fascination al students from the student focus-groups agreed that the context that was used, instead of the traditional book, was *“way more fascinating”* and made them wonder more about what this would bring in the future. In addition, >75% of the students mentioned that they would look up for more information about this topic since the CBL lesson made them curious about the topic. The last aspect that was discussed was the matter of value regarding chemistry education. The students made the remark that the concept of “value” was different to them after the CBL lesson. According to the students, they did not realize the value of chemistry until now. The context that was given was an eye-opener that made them think of chemistry in a broader sense.

4.2 Engagement

Engagement was measured by classroom observations and a teacher interview which focused both on three dimensions of engagement; affective, behavioral and cognitive. The upcoming findings will intent to answer the second research question*: “What level of engagement are observed in the CBL lessons?”* During the classroom observations (real life and video) of the CBL lessons multiple categories of the engagement levels were identified by both observants and will be further discussed in the following paragraphs (4.2.1 till 4.2.3).

4.2.1 Affective engagement

In the affective engagement dimension positive arousal was observed during the CBL lesson, both observants detected 25-50% of the time that the students were amazed and enthusiastic about the content that was given to them. Students gave reactions like: *“This is so cool, normally we don’t get assignments like these”* or “*The teacher is really enthusiastic, nice”*. Positive unaroused was noticeable a lot to most of the time (>50%) and showed that students were calm during the explanation of the teacher and they were alert to what was said. Another element that was striking was the negative unaroused score which both observants scored with the not observed code and gives an indication that 0% of the students showed this type of negative affective engagement.

4.2.2 Behavioral engagement

Participation behaviors where observed during the CBL lessons and showed positive passive behavior some of the time (25-50%). Both observants interpreted this category by the willingness to participate and learn. Most of the groups that participated during the lesson showed that two or three students of each subgroup felt eager to participate and willingness to start with the assignment after the explanation. What also reflected was the active scale which showed that also the abovementioned students a lot to most of the time (>50%) raised their hand and asked more about the assignment or getting clarity about uncertainties about the assignment with question like: *“Mister can you help us with this article, we struggle with the translation”* or *“We think this could be a good approach to solve this problem, are we in the right direction?”*. The second observer mentioned that it was noticeable that most of the time the same students of the group showed the active and positive passive role during the lessons. After this statement the first observer checked the video recordings and confirmed these findings in addition to this observation, the other members of the group showed more negative passive behavior and were <25% of the time disruptive during the working process after the explanation of the teacher. Reactions of these students where: *“I find this way too difficult”* or *“I just don’t get it, hopefully the lesson soon will be over”*.

4.2.3 Cognitive engagement

The involvement of students’ cognitive processes where observed and showed that high ordered thinking was represented a lot of the time (>50%). Students used strategies like predicting and connecting to get to the answer of the assignments and to activate their prior knowledge and showed that high-ordered thinking was applicable during the lessons. Comment during the CBL lesson about early detection of cancer via the blood were: *“I think the early detection of cancer could work if they did some research more to be sure of the effectiveness of the detection procedure”* or *“I think it is plausible that the blood is a good detector of cancer cells since blood can give us so much information about once health already”.* During the observations and the coding, the unrelated thinking process was scored highly by both observants at the time the students had to start working at the assignment (>50% of the time) and was recognized by sentences of students like: *“I don’t get it, let see what lessons comes after this one”* or *“I don’t know what to do anymore, never mind did you learned already for French, David?”.* This indicated that the students were uninvolved with the task and checked out of the high-ordered or required thinking processes.

4.3 Teacher interview

The types of engagement were addressed during the teacher interview and the teachers' perspective was discussed further. Regarding the affective engagement the teacher confirmed that he also detected enthusiasm and amazement during the CBL introduction and a great part of the lesson. The eagerness of students was explained by him as follows: "*These students are bright and capable of doing great thing with their brains, but it is up to us teachers to activate their engagement to the content of the lesson and to us teachers. The CBL lessons are very different from what they are used to receive during their chemistry lesson, but now the students are pulled out of their comfort zone and are challenged to solve the assignment by using different strategies. Since every student can bring own talent and skills to solve these problems, they automatically get eager to solve the assignment".* In addition to this affective engagement also the high-ordered thinking was mentioned by the teacher and linked the "going beyond the basics" to the different strategies that were abovementioned. According to the teacher the CBL approach is also unique since every student can use their own strategies and talent to solve and engage during such a chemistry assignment.

4.4 Opportunity to engage and learn

To map the opportunities that were provided during the CBL lessons, attention was paid to space, activity structure, social and materials and had the purpose to answer the third research question *"What opportunities to engage and learn are observed in the CBL lessons?"* During the lesson it was clear that the teacher paid a great amount of attention to materials like: printed articles, paper for mapping/brainstorming, multimedia, guest speaker and real-life demonstrations with solar driven robots. Al so the outline of the lesson and the activity structure was set in advance. The CBL lesson showed multiple dimensions of structure. The explanation and introduction were fixed, though there was space for questioning, the work process had a more open character and students were free to use their own skills and knowledge to solve the assignment. The role of the facilitator/teacher was less prominent than the start of the lesson. His role was merely to help with minimal information so that the students would cooperate with their own group and get to the solution by themselves. With the enrichment of video fragments and real-life demonstrations, students also received the opportunity to learn from this setting as an addition to the spoken explanation and the written assignment. The space where the CBL lesson was given for the first group, was at their own school in their own classroom and for the second and third group which received the CBL lesson, the University of Twente was used as location since their secondary school was nearby the University. This last location made an impression to the students and their comments sounded like*: "Really nice to have chemistry here today"* and *"Hopefully in a year of two I am also a student here*". Looking at the observation checklist for opportunities to engage, a lot of elements were considered prior and during the CBL lessons.

According to the students of the student focus-groups different materials make a lesson interesting and less dull. Also, the opportunity to "find out for themselves" is a nice way of approach and the students mentioned that a mix of listening and actively doing helped them to learn more on the topic. Al so what was mentioned was the guest teacher that demonstrated robots, which triggered the curiosity of the students and give them the opportunity to engage and learn differently than what they were used to during normal chemistry lessons. A point of attention according to the students was the difficulty degree of some materials. The articles that were given were only in English and the students struggled with the language. Reactions of students were: *"A translation would be much easier, now I am losing time because I have to translate it first"* and *"A translated summary of the most important topic would help tremendously!".* These reactions will be further discussed in paragraph 5.4.

The teacher emphasized the importance of knowing the content as a teacher *"This is a first condition before facilitating a CBL lesson"*. He also mentioned that thinking about materials in advance really helps him to prepare a good lesson *"Thinking of creating opportunities throughout materials in advance gives me the tools to transfer knowledge during my lesson"*. A last remark of the teacher was that practicing with this concept of teaching in context is a key element *"It takes time to master this way of teaching and making adjustments in the role of teacher/facilitator".*

4.5 Relationship between learning activation, engagement and opportunity to engage and learn

The fourth and last research question, evolves around the possible relationship and *"What relationships appear to be present between learning activation, engagement and opportunities to engage and learn"*. The conceptual model underlying this study (see paragraph 2.4) shows that the assumption is made that learning activation influences the engagement and the other way around and that engagement also is being influenced by opportunity to engage and learn. The control group received the intervention and the outcomes of their competency beliefs, fascination and values questionnaires showed slightly higher scores on the means than the comparison group. During the observation, engagement levels were observed and showed that de control group had a high level of positive arousal >50% of the time which showed with emotions like; enthusiasm, amazement and so on. Also, high-ordered thinking was most of the time (>50%) visible which showed actions like; predicting, connecting and so on. These findings are valuable but don't represent a connection between the learning activation and engagement levels of student during the lessons. The focus group interviews gave more in-depth information on this matter. Students mentioned that the more interesting an assignment was, the better they wanted to perform and get to a solution of the problem. What was addressed during the discussions were that students experiences a greater level regarding beliefs on their personal competence after successfully solving a problem. Also, the level of fascination was discussed during the discussion and the comment was made that the CBL was interesting and fascinating so that students felt the desire to learn more from this concept and that their level of fascination increased. Opportunity to engage was also addressed since this is a condition for a good lesson according to the students. Boring materials won't help them to engage to the learning content but the given articles in the CBL lesson were *"way too difficult"* a translated version would work more efficient was the statement of the students. But the different approach of following a chemistry lesson with other materials, thus the CBL approach, was helpful for them to engage during the lesson.

5 Conclusion and discussion

5.1 Conclusion

The overall aim of IMPULS study is to design and develop a chemistry curriculum that can be used by teachers and students to enhance the understanding of chemistry concepts. This research aimed to answer research questions regarding learning activation, engagement and the opportunity to engage and learn with the help of qualitative and quantitative data findings to get more in-depth information on students' perceptions and attitudes on chemistry education that is learned through a context-based approach. The following research questions will be answered:

RQ 1: What characterizes learning activation in CBL and regular chemistry lessons?

RQ 2: What levels of engagement are observed during the CBL lesson?

RQ 3: What opportunities to engage and learn are observed in the CBL lessons?

RQ 4: In the CBL lessons, what relationships appear to be present between learning activation, engagement, and opportunities to engage and learn?

5.1.1 RQ1: Learning activation

The research question *"What characterizes learning activation in CBL and regular chemistry lessons"* is answered in this paragraph. The experimental group (group A) received the CBL lesson and the control group (group B) received the traditional chemistry lesson. For both groups the before and afterwards perceptions were measured with the pre and post-test on Competency beliefs, Fascination and Values regarding chemistry.

Competency beliefs

The greatest decrease on the mean score of the experimental group was the belief of students on the understanding of chemistry information on websites. During the focus group discussion this question was further investigated, and reactions of students gave the explanation that the chemistry lesson, which they've received that day, also let them search on the internet for information. The information was hard to understand according to the students and their confident on their understanding decreased. The first item on the questionnaire asked the students about their competency beliefs on doing chemistry activities in class. This item also showed a decrease in mean and was further investigated during the focus group discussion. The explanation that was given was that they struggled with parts of the CBL lesson and did not manage to solve and practice all the activities that were presented by the teacher. Some of the interviewed students felt lost and doubted about their skills since the content was difficult to them.

Although the abovementioned items indicated a decrease on competency beliefs a slight increase was found on the seventh item which indicates that students felt more competent in coming up with chemistry questions after the CBL lesson and make them eager to collect information by coming up with questions that would help them to complete the tasks of the CBL lesson. Overall no significant differences were found for most part between the before and after filled in questionnaires, so the conclusion that the CBL lesson influences the competency beliefs cannot be made.

The control group showed an increase on the sixth and eight item which both asked at the level of being good in solving a chemistry problem or doing an experiment. The traditional chemistry lesson led to an increase on their competence beliefs on these items.

Fascination

On the level of fascination two items were remarkable and indicated a change on perception of the students. After the CBL lesson they scored higher on wondering how chemistry works. Students mentioned afterwards that the topic was interesting and that they wondered what the future would bring on the treated topic and content of the CBL lesson. The learning activation also seemed to work further than the classroom during this research since students wanted to look up for more information on interesting chemistry activities after the CBL lesson. This could be a coincidence since the significance in this increase of mean could not be proven and this score was based on one CBL lesson, but this item could be interesting to investigate further.

Overall can be said that most of the fascination items increased on means after the lesson. The students pointed out that this kind of content and approach of the subject was far more fascinating and interesting as an assignment than learning from the book and that they felt less bored because the content aroused them and let them use their brain. This correspondents with the previous findings of Dorph, Cannady and Schunn (2016) which state that a chemistry topic can have a cognitive fascination for students and an assignment can serve as intrinsic motivation for them.

Though they mentioned that some parts were too difficult and help of the teacher was needed. Though the significant difference can't be proven abovementioned discoveries are interesting to investigate more thorough.

The control group showed an increase on two items after their traditional lesson which show that they found chemistry slightly more interesting after the lesson and felt more eager in the need to know, how chemistry works. All the six questionnaire items on fascination decreased in mean after the chemistry lesson which shows the biggest contrast with the experimental group since they increased in six items after their CBL lesson.

Values

The findings show that the students values perception increased strongly after the CBL lesson on the item that states that chemistry makes the world a better place to live. The CBL lesson that was given used a contemporary chemistry context (early detection of cancer in blood) that appealed to most of the students. The topic and content were of great value for the future and the society according to the questioned students. This is in line with one of the proposed elements of values according to Eccles (1983) that state that task value is important for future goals as well. Students mentioned in addition that the CBL lesson give them other perspectives regarding the impact and the values of chemistry on the world around them. Eccles (2005) and Lyons (2006) also pointed out that the value of chemistry is impacted if it plays a role in a students' life and society and is in line with the outcomes.

The control group showed an increase on the third item of the questionnaire which shows that after a traditional chemistry lesson they value the way of thinking like a chemist this also occurred with the experimental group after their CBL lesson. The biggest increase of the control group was the perception on chemistry ideas and its value. After the traditional chemistry lesson the control group felt a greater value on this concept.

Differences between groups

The control group showed on competency beliefs higher means in general after their chemistry lesson than the experimental group. As mentioned before, the students struggled with some parts of the CBL assignments since some parts were difficult and new to them. The experimental group felt less competent about their selves while the control group scored higher on competency beliefs after the lesson.

On the level of fascination, the experimental group showed higher levels of being fascinated about chemistry, how it works and the need to know than the comparison group which showed lower scores after their chemistry lesson. What can be said is that something shifted on the fascination levels during the CBL lesson that did not occur during the traditional lesson. The context approach was described as appealing by the students.

The last element of learning activation were the values regarding chemistry. Striking was the difference between groups regarding, knowing chemistry is important for being a good citizen and chemistry make the world a better place to live in. The experimental group showed a slight increase on their value levels after the CBL lesson while the control group showed a slight decrease on these items after their traditional lesson. As above described, student explained their increased value because of the context of the subject that was provided. This approach makes the students think differently about their chemistry values than before the CBL lesson. Overall can be said that there is a difference between the experimental- and control group on their levels of learning activation. Thought significance can't be proven, students' reactions during the focus group discussion helped to get more in-depth information about the items that differed between the first and second questionnaire.

5.1.2 RQ 2: Engagement

Findings were done on the three levels of engagement to answer the research question; *"What levels of engagement are observed during the CBL lessons?"*. Emotions during the observation helped to determine which type of engagement occurred during the CBL lessons.

Affective engagement

During the lessons, positive arousal and positive un arousal was observed most of the time. Students were very enthusiastic about the context which was used for their chemistry lessons and were eager to work on the assignments. The positive un arousal was recognized as the students were calm and alert during the explanation and lesson. Students mentioned earlier that the subjects were interesting and that they were fascinated.

Negative arousal was minimally observed, and signs of bored students were not much represented, apparently the content was interesting enough to get bored. During the processing of the assignment a few students showed frustrated emotions. The student focus-groups interviews made clear that some parts of the assignment were too difficult for them and thus could lead to frustration.

Behavioural engagement

Participation behavior was researched to investigate what types of behavioral engagement occurred. Positive passiveness was observed the most which indicates that students were ready to learn and participate since they were calm and alert to what was explained to them. This also shows that there was less disruptive behavior during the CBL lesson. This type of disruptive behavior was somewhat observed during the last part of the lesson

The active emotion occurred mostly at the start of the working process. Since the assignment and the way of approach was new to them, most students got activated at that point of the CBL lesson by raising hands for questions to get clarification about unclear elements of the assignment.

Cognitive engagement

Involvement with cognitive processes was investigated and findings showed that high ordered thinking of the students represented the cognitive engagement by using strategies like connecting, predicting, problem-solving and so on. This points out that the concept of a CBL lesson addressed to their cognitive skills and that their cognitive skills were used to go beyond the familiar strategies that they've used before on traditional chemistry lessons. Unrelated thinking also revealed itself in the observation findings which indicates that during some parts of the lesson students were distracted from the assignment and did not used their cognition to relate to the assignment.

Overall can be stated that affective, behavioral and cognitive engagement were represented during the CBL lessons and that the positive aspects of each category were represented most of the time and that the negative aspects were less observed. So, it can be said that the positive engagement occurred during the CBL lesson.

5.1.3 RQ 3: Opportunity to engage and learn

The main research question regarding opportunity to engage and learn was *"What opportunities to engage and learn are observed in the CBL lessons*?". Besides the observed findings, the reactions of the students and teacher were insightful to help making conclusions regarding to this topic.

A lot of thought was given during the preparations of these lessons. The expert teacher explained that space, activity structure, socials aspects and materials were considered in advance in to get the most out of the CBL lesson and stresses the importance of the decent preparations. This latter is in line with previous research of Stefanou, Perencevich, DiCintio and Turner (2004) which also illustrated the importance of preparations on the organizational, procedural and cognitive levels.

About the space can be said that the students were more impressed at the University location instead of their own school as location. The University gave an extra dimension and made this new way of learning exciting according to the students. Since there were no significant differences between the control groups on the different location it can't be said that a different location means better understanding of the lesson context and content but does seem to affect the positive arousal and thus the affective engagement of students.

The activity structure can be described as rich, since the CBL lesson showed a lot of elements that make the activities appealing to students. The students explicitly mentioned that the mix between listening and doing was great. Normally the traditional chemistry lessons (besides experiments) have fixed results and there are less opportunities for students to use their own ideas. The teacher also mentioned that the open result idea, helped students to go beyond the basics of what already is familiar to them and so activate their learning. It can be said that the students and teacher are both excited about an activity structure that leads to participation of both groups and a result that offers the possibility to differ and go beyond the traditional conceptions in chemistry.

The social aspect of opportunities to engage showed itself in the different levels of participation of the teacher and the guest teacher during the CBL lessons and had an interactive character. The teacher transferred information but gave the students the opportunities to react and think out loud on the questions and content of the explanation. The guest teacher gave a demonstration which startled the students in a positive way. The conclusion that can be made is that the variety of social interaction and involvement during the CBL lesson and the opportunities to interact of students resulted in actively involved students which were eager to learn.

Materials were considered carefully in the designing process of the IMPULS study prior to the execution of the CBL lessons during this research. The TDT teams considered which materials would be applicable to different kinds of content and with the designed materials the CBL lesson was given. A strong element of the materials was that the content was authentic and represented real-life issues. This was interesting according to the students and was more excited to work with than the chemistry books that were used normally. The use of real-life demonstrations, video clips, pictures and models also were appealing to the students. Also, the variety of materials offers multiple opportunities for students to engage and learn on the topic since students were given the opportunity to connect on their own level and use their own skills to address the content. Students did mention that the articles that were give were way too difficult for them and that the duration of the lesson was too long. What can be said regarding the articles is that the English language led to frustration since the students' level of English was not "on level" for this type of material. Since this topic was mentioned in the focus group discussions, it can be concluded that the articles were not suitable. Another remark that the students made, was the duration of the CBL lesson which took three hours with a break of 10 minutes. Mentioned was that the novelty of this type of lesson in combination with the length of the lesson was too much and that they've experienced some disruptive behavior of fellow students.

Overall multiple opportunities revealed themselves during the CBL lessons and the context approach that was used. Since the active an enthusiastic attitude and feedback of students and the teachers on this approach of offering opportunities to engage and learn was mentioned during the research, this element supports context-based learning.

5.1.4 RQ 4: Relationship between learning activation, engagement and opportunity to engage and learn

The last research question*" In the CBL lessons, what relationships appear to be present between learning activation, engagement and opportunity to engage and learn?"* searched for possible relationships between the concepts underlying this research (learning activation, engagement an opportunity to engage and learn).

During collecting data more than one connection exposed itself. To draw conclusions the following table shows which connections appeared throughout the CBL lessons.

Table 9. *Connections between learning activation, engagement and opportunity to engage and learn.*

Connection			Explanation
Affective engagement	→	Learning activation	▪ Positive arousal (e.g., amazed, enthusiastic, inspired, eager, startled positive) led to fascination on how chemistry works and the need to know.
Behavioral engagement	→	Opportunity to engage and learn	▪ Active participation and taking initiative can be facilitated throughout the social structure of a lesson, where the activity had an interactive structure between facilitator and students and student with peers.
Opportunity to engage and learn	→	Learning activation	▪ Well-considered materials, an activity structure, social structure and space during the CBL lesson helps student to build towards a competent feeling while working on the assignments and address their level of fascination if the interest is

		Engagement	encouraged with the different types of opportunities to engage and learn. ▪ Materials (e.g., authentic, real, examples and so on) that are facilitated can enhance the positive arousal when it inspires students to work with. If the materials are too difficult or don't match with prior knowledge, students can experience negative arousal while working with materials. ▪ The choice of space (e.g., school, museum, school classroom, university and so on) can influence the affective engagement with positive arousal on students' engagement by making them enthusiastic and amazed going beyond their familiar school environment.
Cognitive engagement	→	Learning activation	▪ Required thinking leads to shifts in competency beliefs. If the task connects with what already is familiar, students will thrive on the required knowledge that is present. ▪ High-order thinking can lead to better competency beliefs if the student experiences a success on the delivered work. It also, can make students doubt about their competence if the task is difficult and if the success experience isn't reached.

It becomes clear that learning activation, engagement and the opportunity to engage and learn connect on multiple levels with each other. Chapter 2.4 showed the conceptual model underlying this study and looking at the figure it shows that the assumption was that learning activation and engagement influenced each other and thus had a connection during the CBL lessons and that opportunity to engage and learn influenced the engagement of students. After this research an adjustment should be made (red and blue arrow) to the conceptual model since opportunity to engage and learn revealed to influence learning activation as well.

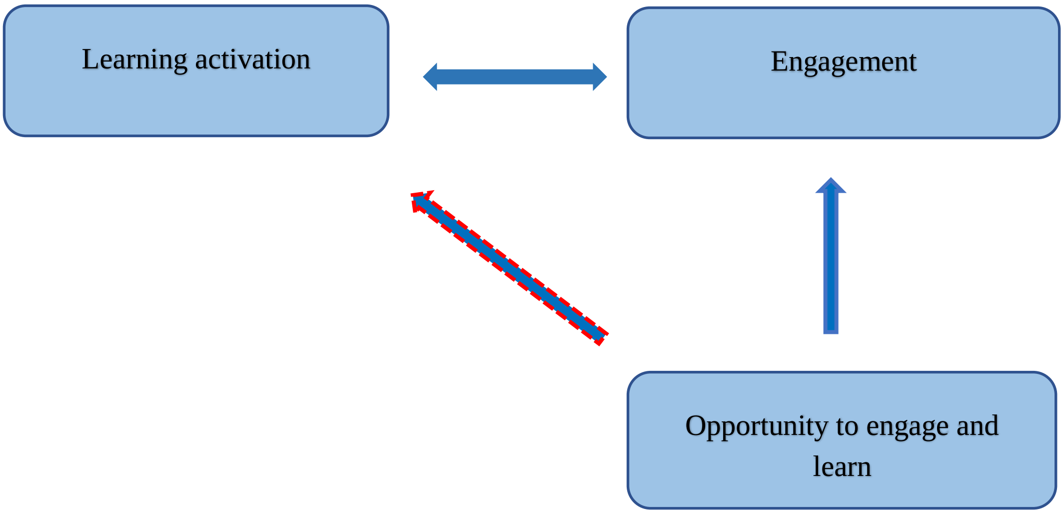


Figure 3. Renewed conceptual model

5.2 Reflection on findings

The aim of this research was to examine the learning activation, engagement and the opportunities to engage and learn of students during a CBL lesson. This research focused mainly on the students' perspective where ass the prior part of the IMPULS study focused more on developing curriculum materials and guidelines for the CBL lesson. The implementation of the CBL lessons was exciting to experience. During this research before the interpretation of the findings certain expectations emerged which were as follows; *"CBL lessons will make students learn more effective", "The materials are interesting and suitable", "There will be a great difference on learning activation between the control and comparison group", "The control group will stay engaged during the CBL lesson"*. These are some of the expectations the researcher had on forehand. Reflection on the findings show that these expectations could partially be confirmed.

Since there was no statistically significant difference between the control- and comparison group, nothing can be assumed regarding the learning activation of these groups. Thought certain items of the competency beliefs, fascination and values showed a significant difference but further research should prove if this occurred because of the CBL lesson or not. Though some findings were interesting to reflect upon. On the competency beliefs level, students that received the CBL lesson felt more competent in coming up with chemistry questions after the lesson. This could imply that the high-ordered thinking of students was addressed after the CBL lesson. During the focus group this implication was confirmed since they had to think on a different level in comparison with normal chemistry lessons. An overall reflection on competency beliefs is that no big differences were found on the learning activation of the students that received the CBL lesson on the before and after data because they only received one CBL lesson and the concept of a context-based approach lesson was new to them. So, the statement that students learn more effective is hard to support since this research only captured one CBL lesson of the experimental groups, further research should investigate this more thorough. The Fascination of the students that received the CBL lesson seemed to be triggered by the fact that the topic was based on a real-life issue, it brought the “reality” closer than the traditional chemistry books. Since the CBL lesson materials were designed with a strong content that relates to real-life issues it seems plausible that the students grew on their level of fascination because of the CBL lesson even though the data don’t show the evidence that it was caused by the CBL lesson. The Value on chemistry increased after the CBL lesson and could imply that making use of a context around a real-life issue helps students to relate to the world around them and the contribution of chemistry to society. This finding was surprising and a good predictor for enhancing the learning activation during the CBL lesson.

On the level of engagement, the students that received the CBL lessons, students mentioned that they found the topic very interesting and fascinating. This might be the explanation that this outcome led to higher levels of engagement (e.g., arousal, enthusiasm). Also, the high levels of calmness and alert engagement could indicate that a) the content is very fascinating and b) the teacher knows how to transfer the content of the context to keep the students “a board” during the lesson and seems of great importance. Another remarkable finding was that some students’ attention dropped after two third of the lesson. This could imply that the duration was too long for the CBL lesson and that this explains why some students’ engagement lacked. Another explanation could be that they found the assignments and novelty of the CBL too hard to grasp and thus their involvement also slipped somewhat.

What did become clear is that students did enjoyed the CBL lesson and on all the researched levels a reaction occurred during the CBL lesson which was exciting to discover. The materials were studied by the researcher and seemed suitable for the students and the CBL lesson. Thought the reactions of the students showed that this point needs to be addressed in the future. After explanation of the students on the focus group it became clear that the level of some materials should be considered more thorough since the goal is not so much to improve their English but to work upon their chemistry knowledge and learning via a context-based approach. Though overall the materials were received well, and students were interested to study them. This could lead to higher levels of engagement since the materials gave them an opportunity to engage. These finding were insightful and give inspiration for the recommendations and implications that will be further treated in the upcoming paragraph. Overall the findings did not confirm all the expectations but provide a lot of interesting information that could lead to more research and improvement of the CBL curriculum and its lessons.

5.3 Limitations of the study

This research was done as a part of the IMPULS study. Since the study was already started, some elements were fixed on forehand. For example; the participating schools were known and the students that received the CBL lesson received information regarding the project as well. It could imply that students were partially biased, since they were aware of their “condition” in the research.

The number of participating students was *N=116*, this number could be questioned whether the sample size is big enough to detect effects between the experimental and control condition. Also, the number of CBL interventions could be limitation since the experimental groups only received one CBL lesson and the data on effects is limited also a long-term conclusion cannot be made at this point of research. More CBL lessons could identify effects on the long term that can be related to elements of the CBL lessons which for now is limited.

A last limitation was that the experienced teachers who thought the CBL lessons were a part of the IMPULS study. Since there was the possibility of conflict of interest, the teacher interview information regarding the research could only be used as additional information since the risk of being biased in his opinion.

5.4 Recommendations for practice and future research

5.4.1 Recommendations for practice

Recommendations for further practice can be done on the level of CBL lesson materials. It would be that the materials are designed on the level of students that means that grade (4-5 VWO) is considered, language skills and existing fundamental chemistry knowledge. This could make the transition to the CBL lesson materials more gradually. Also, it would be a good suggestion to use the CBL materials more frequently, so that the students get familiar with the concept of context-based learning and grasp the “new way” of working with a chemistry content. By getting more familiar with the CBL approach, levels of learning activation and engagement in chemistry could increase. Another suggestion would be that the duration of a CBL lesson should be reconsidered for the future. It could help to half the duration for the first set of CBL lesson so that the students can slowly get familiar with this CBL approach. When the students are more known with the approach an extension of duration could be made.

The first part of the IMPULS study already mentioned that more practice for teachers also would be beneficial. This is in line with the recommendation that can be made after researching the CBL lessons. Teachers also need to grow in this way of teaching and get familiar with the materials just like the students. An extension of the pilot period could be a good endorsement to work towards a successful implementation of the new chemistry lesson approach and make the CBL approach work.

A last recommendation would be that regular reflection on the implementation of the CBL lesson would be sensible. The students can provide feedback as well as the teachers in an ongoing conversation that can lead to continuous improvement of the CBL lesson materials and help to get the most out of all the involved parties.

5.4.2 Recommendations for research

This research and the prior findings in the first part of the IMPULS study showed a great number of findings that can be used for further research. In this part of the research a few elements draw attention that could be further researched in the future.

A first recommendation would be that the research would be done on the long-term which means that the period of implementation and testing of the CBL lesson materials will be studied for a longer time. The research now only researched one CBL lesson over a period of three months with a small sample of students that received the CBL lesson. Though it was interesting to see what findings came up with the respondents of the study, a larger sample could help to get more information on the effect and then also the effects on the longer term that occur during and around the CBL lessons.

Another recommendation would be to repeat the second set of questionnaires after a longer period. In this research the questionnaires were taken before and after the CBL lesson and the traditional chemistry lessons. When a second set is repeated at a later stage, effects on learning activation could be more contrasting than what was discovered during this research.

A last recommendation would be to gather more qualitative data with the help of teachers interviews with teachers that are not involved in this study. This could lead to other insights on the implementation of the CBL lessons and what works and could be enhanced so that the CBL approach works towards higher learning activation and engagement of the students during the chemistry lessons.

5.5 Concluding remarks

What became clear during this research was the rich body of the context-based approach. The renewed way of transferring chemistry content with the help of contemporary topics in a context was unique to experience. The reactions of the observed and interviewed students were valuable for this and further research and showed that students engaged to the content and felt a renewed sense of competence beliefs, fascination and values towards chemistry. The CBL lessons still need some attention to refine but the lessons already proven to be an absolute enrichment for the chemistry education according to the students that participated and could be on its way to become an important part of the chemistry education curriculum of the 21st century.

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Appendices

Appendix A: Questionnaire competency beliefs

Vraag 1	Ik kon de natuur/scheikunde opdrachten in de derde klas maken	○ altijd ○ bijna altijd ○ soms ○ nooit
Vraag 2	Als ik naar een natuur/scheikunde museum zou gaan, zou ik begrijpen wat er werd getoond op:	○ alle gebieden ○ bijna alle gebieden ○ sommige gebieden ○ geen enkel gebied
Vraag 3	Ik kan natuur/scheikunde informatie begrijpen op websites voor mijn leeftijd	○ alle websites ○ bijna alle websites ○ sommige websites ○ geen enkele website
Vraag 4	Als ik een eigen natuur/scheikunde project na schooltijd mocht doen, zou dat:	○ geweldig zijn ○ leuk zijn ○ wel oké zijn ○ niet leuk zijn
Vraag 5	Als ik voor natuur/scheikunde aan een klassenopdracht zou werken, zou ik de stof voor volwassenen begrijpen die in de boeken staat	○ alles ○ bijna alles ○ sommige stukken ○ weinig
Vraag 6	Ik denk dat ik erg goed ben in: een natuur/scheikunde proef verbeteren die aanvankelijk niet lukte	○ JA! ○ nee ○ NEE! ○ ja
Vraag 7	Ik denk dat ik erg goed ben: in het bedenken van vragen over natuur/scheikunde	○ JA! ○ ja ○ nee ○ NEE!
Vraag 8	Ik denk dat ik erg goed ben in: experimenten doen	○ JA! ○ ja ○ nee ○ NEE!

Appendix B: Questionnaire fascination

Vraag 1	Ik ben benieuwd hoe scheikunde werkt	○ elke dag ○ een keer per week ○ een keer per maand ○ nooit
Vraag 2	In het algemeen, als ik met scheikunde bezig ben dan:	○ vind ik het geweldig ○ vind ik het leuk ○ vind ik het niet leuk ○ haat ik het
Vraag 3	In het algemeen vind ik scheikunde:	○ heel interessant ○ interessant ○ saai ○ heel saai
Vraag 4	Als een interessante scheikunde opdracht afgelopen is, dan ga ik zelf op zoek naar meer informatie hierover	○ JA! ○ ja ○ nee ○ NEE!
Vraag 5	Ik moet weten hoe dingen werken	○ JA! ○ ja ○ nee ○ NEE!
Vraag 6	Ik wil alles lezen wat ik kan vinden over scheikunde	○ JA! ○ ja ○ nee ○ NEE!
Vraag 7	Ik wil alles weten over scheikunde	○ JA! ○ ja ○ nee ○ NEE!
Vraag 8	Ik wil alles weten over wat scheikundigen doen en hoe ze dat doen	○ JA! ○ ja ○ nee ○ NEE!

Appendix C: Questionnaire values

Vraag 1	Kennis van scheikunde is belangrijk voor:	○ elke baan ○ de meeste banen ○ sommige banen ○ geen baan
Vraag 2	Kennis van scheikunde helpt me te begrijpen hoe de wereld werkt	○ altijd ○ bijna altijd ○ soms ○ nooit
Vraag 3	Denken als een scheikundige helpt me bij:	○ al mijn schoolvakken ○ de meeste schoolvakken ○ sommige schoolvakken ○ geen enkel schoolvakken
Vraag 4	Ik denk dat scheikundigen de belangrijkste mensen op de wereld zijn	○ JA! ○ ja ○ nee ○ NEE!
Vraag 5	Ik denk dat scheikunde belangrijker is dan al het andere	○ JA! ○ ja ○ nee ○ NEE!
Vraag 6	Scheikunde maakt de wereld een betere plek om te leven	○ JA! ○ ja ○ nee ○ NEE!
Vraag 7	Kennis hebben van scheikunde is belangrijk om een goede burger te zijn	○ JA! ○ ja ○ nee ○ NEE!
Vraag 8	Ik denk dat scheikundige ideeën, waardevol zijn	○ JA! ○ ja ○ nee ○ NEE!

Appendix D: Observation tool – engagement

ENGAGEMENT OBSERVATION SUMMARY

Code	*Cognitive*	*Behavioral*	*Affective*
4 A lot to most (> 50%) 3 Some (25-50%) 2 Rarely (< 25%) 1 Not observed (0%)	Involvement with cognitive processes: _____**High-Order Thinking:** Going beyond the basics (e.g., predicting, connecting, problem-solving, claim-making, noticing similarities/ differences, metacognition) _____**Required Thinking:** Doing the basics (e.g., attentive, focused on task, reciting, naming, identifying, discussing procedures, complete worksheet as directed) _____**Unrelated Thinking:** Uninvolved with task _____**Unknown Thinking:** Unknown processes	Participation behaviors: _____**Active.** Active, takes initiative, eager to participate. *(e.g., hand raising, asking and answering questions are ok to code as Active in a setting without physical opportunity)* _____**Passive +.** Ready to learn and participates. _____**Passive -.** Doesn't take initiative, gives up, unprepared, or distracted. _____**Disruptive.** Actions interfere with self and other's learning.	_____**Positive Aroused:** Amazed, Joyful, fun, happy, enthusiastic, eager, inspired, determined, startled-positive _____**Positive UA:** Alert, calm, relaxed, at ease _____**Negative UA**-Bored _____**Negative UA**-Sad/Drowsy/tired _____**Negative Aroused:** Distressed, upset, angry, frustrated, worried, startled-negative