Students as Scientists
A study of motivation in the science classroom

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Appendices
School science and mathematics have been criticized for being difficult, de-contextualised and teacher-centred. This thesis concerns student motivation in science and mathematics in secondary school, and in particular student motivation in relation to student-teacher-scientist partnerships (STSPs) and an authentic science task called the Medicine Hunt where students help scientists to find new antibiotics. The purpose of this dissertation is to interrogate the importance of authentic tasks for motivation in the science classroom. The thesis takes a starting point in motivation theories, with self-determination theory (SDT) in focus, and also builds on the hierarchical model of intrinsic and extrinsic motivation (HMIEM). A mixed-methods approach is used first, to find out what factors are important for students’ positive emotions and experiences in the classroom, and second, to learn more about the importance of authentic tasks using student interviews and observations in combination with questionnaires that evaluate students’ motivation. The studies reveal that the notion of having learnt something and intrinsic motivation are central for students’ positive emotions. Further, many situational factors, such as teacher support, autonomy, clear goals, and novelty of the task are central for both positive emotions and experiences in science and mathematics. Regarding the Medicine Hunt, students were positive and referred most of their positive experiences to science-related aspects, and the novelty of authentic science. Teachers gave different opportunities for competence, autonomy or relatedness when implementing the project in their classrooms, and these differences were more important for students’ initiatives and outcomes than students’ initial contextual motivation for school science. Students’ contextual motivation for science can change and the Medicine Hunt arrested the well-documented decline in students’ intrinsic motivation for science during the secondary school years. This thesis argues that authentic tasks implemented as STSPs such as the Medicine Hunt can contribute considerably to school science by providing motivating situations that channel students’ positive emotions and positive experiences, and that is possible to create authentic science learning situations in which both more and less motivated students can flourish. The findings highlight the teachers’ role in supporting the students’ process of extending their understanding of what science can include and in supporting students’ confidence as they adopt a broader and more authentic view of science when learning as part of a successful authentic STSP science project. The findings also suggest that more research focussing on motivation in different authentic situations, and how students’ experiences of authentic science can affect motivation in the longer term, is needed.
Forskning på schemat: högstadieelevers motivation för naturvetenskap

Det finns flera olika anledningar till att naturvetenskap är ett viktigt ämne i skolan. Två anledningar, som till exempel skrivs fram av Aikenhead (2006), är dels att få framtida medborgare som har grundläggande naturvetenskapliga kunskaper för att delta i samhällsdebatt och fatta beslut grundade i naturvetenskapliga argument och dels att förse industri och forskning med framtidens naturvetare och ingenjörer. I svensk skola läser både elever som främst vill använda naturvetenskap i sin roll som samhällsmedborgare och därtill elever som planerar en karriär inom naturvetenskap tillsammans i hela grundskolan.

Vilket syfte som ses som primärt med den naturvetenskapliga undervisningen påverkar vad den naturvetenskapliga undervisningen innehåller. I läroplanen för den svenska grundskolan (Skolverket, 2011) finns, utöver de ämnesområden eleverna ska tillåtna sig kunskaper i, tre kompetenser som de ska utveckla genom undervisningen i kemi, biologi och fysik. Dessa kompetenser rör att använda naturvetenskapliga kunskaper för att “granska information, kommunicera och ta ställning” (s 111) i olika samhällsfrågor, att genomföra systematiska undersökningar samt att använda “begrepp, modeller och teorier för att beskriva och förklara” (s 112) naturvetenskapliga samband. Tillsammans lyfter kompetenserna fram naturvetenskapliga aspekter som är av vikt både när naturvetenskapen ska användas i vardagliga situationer och inom en naturvetenskaplig karriär.


Detta kan till exempel ske genom att koppla undervisningen till ett autentiskt forskningsprojekt. Avhandlingen studerar olika aspekter av elevers upplevelser och motivation när de deltar i ett sådant forskningsprojekt. Vidare diskuterar den hur deltagandet bidrar till elevers lärande i och motivation för naturvetenskap i ett längre perspektiv.
Bakgrund

Den här typen av samarbeten kan vara svåra, men samtidigt mycket givande för alla inblandade. Oss vet att detta påstående är störd av typiskt misstag. När forskning har blivit annat visat positiva resultat i form av fördjupat lärande, mer positiva attityder till naturvetenskap och till forskare, samt glädje och stolthet över det delta i autentisk forskning. Förutom dessa resultat finns också potential för projekt som Forskarhjälpen–Medicinjakten att stödja lärare och elever i arbetet mot läroplanens ämnesspecifika mål och de övergripande kompetenser som beskrivits ovan. Sammanfattningsvis tyder tidigare forskning på att en bättre förståelse för elevers motivation i samband med autentiska forskningsprojekt kan bidra till vår förståelse för hur skolans naturvetenskap kan utvecklas och bli ännu mer ändamålsenlig, både för elever som vill använda sina kunskaper i vardagliga sammanhang och för de som planerar en framtid inom något naturvetenskapligt yrke.

Teoretiska utgångspunkter

Vidare bygger SDT på att alla individer, i det här fallet elever, är aktiva och utforskar om tre grundläggande psykologiska behov är uppfyllda, nämligen känslor av kompetens, autonomi och samhörighet (Ryan & Deci, 2000b). Känslan av att vara kompetent får eleven till exempel om han ställs inför en uppgift som är lagom svår och samtidigt utmanande, och om eleven ser sin roll i lärandet. Känslan av autonomi får eleven att möjlighet till aktiviteter utifrån sitt eget intresse och sina egna värderingar, om eleven


Hittills har främst kvantitativa metoder, baserade på SDT och andra motivationsteorier, använts inom motivationsforskningen i naturvetenskapens didaktik såväl som inom andra traditioner. Forskningen har till exempel visat att inre motivation kan relateras både till goda skolresultat och val av framtida karriär inom ämnet, och det är därför av värde att förstå mer om hur motivation fungerar i klassrummet. Detta kan uppnås genom att använda sig av kvalitativa klassrumsstudier.

**Syfte och frågeställningar**

Syftet med avhandlingen är att undersöka hur naturvetenskapliga projekt, som liknar de som yrkesverksamma naturvetare och forskare ställs inför, kan bidra till elevers motivation för naturvetenskap i skolan. I synnerhet kommer jag att undersöka hur ett autentiskt forskningsprojekt, med innehåll, frågor och metoder som används av professionella forskare, implementeras i skolans naturvetenskap, och om detta arbetssätt kan bidra till elevernas positiva upplevelser av naturvetenskap. Avhandlingen har följande övergripande frågeställningar:

- Vilka faktorer i klassrummet är viktiga för elevers motivation och positiva upplevelser?
- Hur arbetar elever med en autentisk ansats i skolans naturvetenskap, och hur förhåller sig arbetet till elevernas motivation och upplevelser?

Mer detaljerade frågeställningar presenteras i de olika delstudierna.
Design och metoder

Avhandlingens fyra studier är baserade på en design i två delsteg, del A och del B. Del A är en storskalig enkätundersökning som tar reda på vilka faktorer som är viktiga för elevers positiva känsloupplevelser i matematikklassrummet. Opublicerade data insamlade med samma enkät i naturvetenskapliga klassrum visar att det är stor överensstämmelse i vilka faktorer som är viktiga för elevers positiva känsloupplevelser i matematik och naturvetenskap. Del A ligger därför till grund för urval av personliga faktorer och klassrumsfaktorer som studeras i del B. Del A redovisas i detalj i studie I. Del B är en mixed-methods studie av motivation och upplevelser hos högstadiellever som deltar i projektet Forskarhjälpen–Medicinjakten, där de provar på att arbeta som forskare tillsammans med sina lärare från sina egna klassrum. Del B är baserad på enkäter, intervjuer och video- och ljudupptagningar som analyseras med avseende på olika motivationsaspekter. Del B redovisas i detalj i studierna II, III och IV.


Resultat
Första frågeställningen är: *vilka faktorer i klassrummet är viktiga för elevers motivation och positiva upplevelser?* Denna frågeställning besvaras genom resultat från Studie I och III. Studie I visar att de viktigaste personliga faktorerna för positiva aktiverande emotioner i klassrummet var inre motivation, bemästrandemål och upplevt lärande. Exempel på viktiga situationsfaktorer var läarens entusiasm, läarens stöd, autonomi, kompisarnas attityd till ämnet, uppgiftens nyhetsvärde och hur tydligt lektionens mål var. Studie III visar att 21 av de 24 deltagande eleverna var positiva till den lektion i Forskarhjälpen–Medicinjakten som studien avsåg, och att de flesta anledningar som eleverna angav var kopplade till Forskarhjälpen–Medicinjakten och/eller till naturvetenskap i allmänhet. Anledningarna var i mycket liten utsträckning kopplade till faktorer som inte hade med naturvetenskap att göra. Många elever lyfte fram att det var positivt att få arbeta praktiskt, att få arbeta undersökande, att lära sig mer om hur naturvetenskap är "på riktigt" samt att få arbeta med samma projekt under längre tid och få kontinuitet i undervisningen och lärandet. De uppskattade också variationen i undervisningen under Forskarhjälpen–Medicinjakten. Sammantaget är många av de viktiga faktorerna i både Studie I och III relaterade till elevernas känslor av kompetens, autonomi och samhörighet och många är möjliga för läaren att påverka i klassrummet.

Andra frågeställningen är: *hur arbetar elever med en autentisk ansats i skolans naturvetenskap, och hur förhåller sig arbetet till elevernas motivation och upplevelser?* Denna frågeställning besvaras genom resultat från Studie II, III och IV. Eleverna fick något varierande möjligheter för sitt arbete i de tre klassrummen som studien innefattade, eftersom lärarna hade olika ramar att arbeta ifrån och eftersom lärarna planerade och genomförde lektionen på olika sätt. Klassrummen skilde sig åt i vilka möjligheter läaren gav eleverna för att känna kompetens, autonomi och samhörighet. Det fanns skillnader i hur eleverna tog initiativ, arbetade i grupp och i deras slutresultat på den utförda uppgiften. I det första klassrummet, med goda möjligheter att känna kompetens och samhörighet och vissa möjligheter att känna autonomi, slutförde alla elever uppgiften, oberoende av deras motivation för naturvetenskap och eventuella brister på initiativ under lektionen. I det andra klassrummet, med goda möjligheter att känna autonomi och samhörighet och vissa möjligheter att känna kompetens, dock med oklara instruktioner, slutförde endast en av de fyra eleverna uppgiften. I det tredje klassrummet låg läarens fokus på förfarandet, och möjligheterna att känna kompetens, autonomi och samhörighet var begränsade. Här tog flest elever initiativ och hade väl fungerande grupparbeten. Tre av fyra slutförde uppgiften. Inga mönster kunde ses i hur elever med olika typer av övergripande motivation för naturvetenskap tog initiativ, arbetade i grupp...
eller slutförde uppgiften. Eleverna arbetar alltså i stor utsträckning väl med en autentisk ansats i skolans naturvetenskap, och skillnader i elevernas arbete är i högre grad kopplade till möjligheterna som ges i klassrummet än till elevernas övergripande motivation för naturvetenskap.

**Diskussion**

Syftet med avhandlingen var att undersöka hur naturvetenskapliga projekt, som liknar de som yrkesverksamma naturvetare och forskare arbetar med, kan bidra till elevers motivation för naturvetenskap i skolan. Resultaten ovan visar att Forskarhjälpen-Medicinjakten är en positiv upplevelse som bidrar till elevernas syn på naturvetenskap, och att engagemanget i klassrummen är högt. Vidare hänger elevernas initiativ och resultat i klassrummen såväl som deras positiva upplevelser av Forskarhjälpen-Medicinjakten i hög grad samman med möjligheterna till att känna kompetens, autonomi och samhörighet i klassrummet och i lägre grad med den inre och yttre motivation för naturvetenskap som eleverna har.

Positiva upplevelser i klassrummet kan påverka elevers motivation för naturvetenskap på längre sikt (Lavigne & Vallerand, 2010), dock är det oklart vilken typ av positiva upplevelser som kan påverka och i vilken utsträckning dessa upplevelser behövs för att göra skillnad. Forskarhjälpen-Medicinjakten bidrar med en autentisk ansats som integreras i den vanliga naturvetenskapliga undervisningen under sex månader och som en majoritet av eleverna upplever som positiv med hänvisningar till naturvetenskapliga aspekter av arbetet. Tidigare forskning visar entydigt att elevers motivation för naturvetenskap minskar under högstadieåren (Potvin & Hasni, 2014). I relation till denna väl dokumenterade nedgång är det relevant att notera att både elevers inre motivation och deras planer för att studera och arbeta med naturvetenskap i framtiden är oförändrade under de sex månader de deltar i Forskarhjälpen-Medicinjakten. Därför bidrar avhandlingen med detaljerad kunskap om en typ av situation där elevers motivation för naturvetenskap på längre sikt påverkas av positiva upplevelser i klassrummet genom att bromsa in den nedåtgående trenden som annars är tydlig i högstadieåren.

Utöver denna slutsats bidrar avhandlingen med teoretisk/metodologisk kunskap genom mixed-methods studiens triangulering av motivationsaspekter i naturvetenskapsklassrummet. Eleverna som intervjuas är mycket positiva till arbetet med Forskarhjälpen-Medicinjakten, och ser alla ut att arbeta engagerat. Vid närmare analys av video- och ljudupptagningar framgår dock kvalitativa skillnader mellan olika elever och klassrum. Trots att utfallet i termer av upplevelser och engagemang är positivt visar enkätundersöknings på tvetydiga resultat. Inre motivation och planer för framtida deltagande i naturvetenskap förblir oförändrade, men andra av elevernas motivationsrelaterade egenskaper minskar under
tiden de deltar i projektet. Därför är det mycket viktigt att fortsätta att utveckla teorier och genomföra empiriska studier om elevers motivation i klassrummet med kvalitativa angreppssätt så att vi får mer förståelse för processerna i klassrummet än vad som kan mätas med enbart enkätstudier. Den här avhandlingen innehåller ett första stege på vägen.

Sammanfattningsvis kan autentiska frågeställningar och arbetssätt ha många fördelar relaterade till elevers motivation för naturvetenskap på kortare och längre sikt. Dessutom går de aspekter som eleverna främst uppskattar i Forskarhjälpen i stor utsträckning att uppnå i vanlig undervisning, oberoende av möjligheter att delta i något projekt som Forskarhjälpen–Medicinjakten. Dessa aspekter är att arbeta praktiskt, att arbeta undersökningsartade, att lära sig mer om hur naturvetenskap är "på riktigt", samt att få arbeta med samma projekt under längre tid och därmed få kontinuitet i och variation i undervisningen. Autentiska frågeställningar och arbetssätt är också ett gott sätt att introducera ett mer undersökningsartade arbetssätt och ge arbetet en kontext, i och med kopplingen till aktuella frågor och pågående forskning. Vidare stöds läroplanens övergripande mål med den naturvetenskapliga undervisningen: att elevernas ska utveckla kompetenserna att granska information, kommunicera, ta ställning, genomföra systematiska undersökningar och att använda vetenskapliga begrepp, modeller och teorier för att beskriva och förklara sammanhang. Vid planering av undervisning med autentiska frågeställningar och arbetssätt är det viktigt att tänka på att låta ovan nämnda aspekter ta plats i undervisningen och att eleverna behöver stöd så att de kan känna kompetens, autonomi och samhörighet i klassrummet när de utvecklar kunskap om nya arbetssätt och möter nya ansatser inom naturvetenskapliga ämnen.
List of studies


For study I, all five participants in the project *Interactions between the learner and the learning situation: effects on affective experiences and learning outcomes* collaborated to construct, test and evaluate questionnaires. Data collection, data analysis and writing the paper were done as collaboration between the three authors. I took an active part and responsibilities in all parts of the process. The final manuscript for study I was approved by all authors before submission.

For studies II, III and IV, data collection was planned and performed in collaboration with a colleague who worked within the project *Help a scientist*, and with my main supervisor. I had the overall responsibility of planning methods and doing data collection, but all steps were discussed in relation to interests from both *Help a Scientist* and *Interactions between the learner and the learning situation: effects on affective experiences and learning outcomes*. I have done all data analysis and the writing for studies II, III and IV. However, study II is co-authored with the collaborator from *Help a Scientist* since she did a substantive part of the data collection and wrote a degree-project (Lindberg, 2012) based on the data. Study II differs from the degree project by including an overlapping but different dataset, using more advanced methods for statistical analysis and is written with a different overall framing and argumentation. The final manuscript for study II was approved by the co-author before submission.
1. Introduction

This thesis concerns students’ motivation for and experiences of science and mathematics in school, focussing on the implementation of an authentic task in the school science classroom. The role that authentic aspects have for students’ motivation, students’ experiences and students’ engagement for science is central. In this thesis, ‘authentic’ describes what scientists encounter in their professional lives. Many students consider science in school difficult and irrelevant to their everyday lives (Lyons, 2006), and research has repeatedly shown downward trends in motivation for and attitudes towards science in the early teenage years (e.g. Gottfried, Fleming & Gottfried, 2001; Potvin & Hasni, 2014; Simpson & Oliver, 1990; Zusho, Pintrich & Coppola, 2003). This is troubling when today’s society increasingly requires a scientifically literate population.

Most people agree that it is important to study science in school, but the reasons why people should be educated in scientific literacy diverge. Aikenhead (2006) asks for what purposes we educate people and argues for a humanistic perspective in school science, one that “promotes practical utility, human values, and a connectedness with societal events to achieve inclusiveness and a student orientation” (p. 22). He further highlights the competition between the humanistic perspective and the traditional perspective that “promotes professional science associations, the rigors of mental training and academic screening to achieve exclusiveness and a scientist orientation” (p. 22). The political incentives behind the traditional perspective include providing industry and research with employees for increased future innovation and economic growth, whereas the humanistic perspective includes a broader group of students with the aim of providing a level of scientific literacy to allow participation in popular debate that demands scientific knowledge. Naturally, in a mixed school class where science is compulsory for all, there will be students who plan for a career in science and need a good knowledge base to enter their chosen profession. Further, there will be students who do not have future plans that include science, and are likely to “just” use their science knowledge for citizenship. School science needs to give opportunities to foster these, and other, groups, often with all groups of students mixed in the same classroom.

The reasons for teaching or learning science impact what school science should include, and how school science should be taught. In the Swedish national curriculum (Swedish National Agency for Education, 2011) there are, in addition to topic-specific goals, three explicit long-term goals that define the competences science teaching should give students the opportunity to develop. The first goal is to use knowledge in science to “examine information, communicate and take a view” (p. 105) in questions related to science in everyday life, such as health, sustainability, energy and
environment. This parallels the humanistic perspective argued for by Aikenhead (2006), and is central for developing a view of science as open for interpretation and argumentation in relation to social questions, rather than a simple view of science as something fixed and incontestable. The second goal is to carry out systematic studies in science. This is not only a key skill in the daily work of scientists, but also central for citizens who want to evaluate research studies, and to be able to interpret differences between information retrieved from science investigation and information retrieved from less scientific sources. The third goal is to use concepts from science, its models and theories to describe and explain relationships in the human body, society and nature. These three long-term goals focus on competences essential both for students choosing science as a future career and for students who want science-skills for everyday life.

Supporting students' development towards a competence to examine information, communicate, hold a viewpoint, carry out systematic studies and use scientific concepts, models and theories to describe and explain relationships is not achieved by a strictly traditional way of teaching science that is often described as focused on facts and with cook-book style labs. Instead, supporting the development of these competences requires teaching that focuses on inquiry and reasoning, with open-ended experiments, and time for discussion and argumentation. Such an approach to school science would resemble how scientists work in authentic research laboratories and would contribute complementary aspects to everyday school science. Moreover, such an approach is more student-oriented and has the potential to increase students' motivation and positive experiences in relation to their science learning.

Positive affective experiences are important for students' learning (e.g. Pekrun, 2006), and the key role teachers are expected to play in supporting students' affective experiences is clear in the Swedish national curriculum. Teachers should, for example, “take into account each individual’s needs, circumstances, experiences and thinking”, and “reinforce the pupils’ desire to learn as well as the pupil’s confidence in their own ability” (Swedish National Agency for Education, 2011, p. 16). Needs, desire to learn and confidence in ones’ abilities, as well as relevance and usefulness, are all key elements in the concept motivation, that is often defined as “an internal state that arouses, directs and sustains students’ behaviour” (Koballa & Glynn 2007, p. 85). In this thesis, however, I have chosen to see motivation as an interplay between internal and external factors that stimulate peoples’ energy, commitment, interest and effort to start up and continue to work towards different goals. This allows the context a more central role and includes each person’s motivation to be seen both as a state and a trait. I combine various perspectives on how internal and external factors associated with authentic science aspects relate to student motivation.
2. Purpose, overview and research questions

The purpose of this thesis is to interrogate the importance of authentic tasks for motivation in the science classroom. In particular, I will explore how an authentic science project, with content, questions and methods similar to those used by working professional scientists, can contribute to school science, and if this can enhance students’ positive affective experiences of science.

The thesis takes its theoretical starting point in motivation theories, and as the work developed, my view of motivation and how motivation can be studied also developed. To increase the understanding of motivation in the classroom, I include frameworks for motivation that focus more on the context. The thesis consists of four studies designed from two methodological starting points, hereafter called Part A and Part B (see Figure 1). Part A is a large-scale questionnaire study aiming to predict what factors are most important for students’ positive activating emotions in the classroom. This part resulted in study I. Part B is a mixed-methods study of student motivation when students are introduced to authentic science through a student-teacher-scientist partnership (STSP) called the Medicine Hunt. This part resulted in studies II, III and IV.

In Part A, student motivation is represented by variables extracted from motivation theories such as self-determination theory, achievement goal theory and expectancy value theory (see Section 3.1). The classroom context is a range of situations representing ordinary mathematics classrooms. Study I asks what factors are most important for students’ positive activating emotions (Pekrun, 2006) in the classroom.

![Figure 1. Overview of the thesis including the two parts A – Predicting motivation and B – Students as Scientists, and the four studies I, II, III and IV.](image)
Part B aims to achieve a deeper understanding of student motivation by using not only the variables that are shown to be most important for students' positive activating emotions in part A, but also students' experiences described in their own words, and students' initiatives, group work and outcomes in the classroom. The context for part B is the STSP, the Medicine Hunt (see Section 4.2.2), in which students are introduced to authentic science. Study II is based on questionnaires, and investigates if students' motivation for school science and other motivation related factors change during the period they work with the Medicine Hunt. Study III is based on interviews and investigates what students refer their positive experiences to, and further, if these experiences are connected to authentic science, if they are general for science, or if they are unrelated to science. Study IV is based on video-observations and examines how the Medicine Hunt is implemented in three classrooms, and focuses on what opportunities for motivation students are given and how they engage in a specific task.

The discussion of the thesis results demonstrates how these findings increase our understanding of how an authentic science project, with content, questions and methods that are similar to those used by professional scientists, can contribute positively to Swedish school science and to students' motivation for learning science. The discussion is guided and framed by two questions that aim to synthesise results and perspectives from the studies. The questions are: (1) What classroom factors are important for students' motivation and positive experiences? Studies I and III contribute to question 1 with general classroom factors and students' experiences; (2) How do students with different contextual motivation work with, and how do they experience working with, an authentic approach to science? Studies II, III and IV contribute to question 2 with experiences and engagement studied in relation to the same science lesson.

The research presented in this thesis was carried out as one part of the Swedish Research Council's funded project “Interactions between the learner and the learning situation: effects on affective experiences and learning outcomes” (2007-3216), that aimed to investigate: i) how the individual's epistemological beliefs and pre-knowledge interact with the learning characteristics of the situation in forming affective experiences; ii) what situational characteristics are important in this context; and iii) how affective experiences affect learning outcomes. Within this frame, my thesis focuses on affective experiences, by using the motivation-framework including epistemological beliefs that was developed within the project, and by focusing on individual and situational characteristics.
3. Background

In this section I provide an overview of theoretical and empirical studies on motivation and authentic science of particular relevance to the thesis. I begin by introducing motivation theories used in education, and defining the components of the conceptual framework used in Part A of the study presented in this thesis, before presenting the frameworks for motivation in the classroom that are additionally used in Part B. Thereafter, in Section 3.3, I review previous research on motivation in science education, particularly the science education research that considers which factors are important for students’ motivation, and why motivation is important for students’ learning and future choices. Then, before I summarise the background in relation to the empirical studies in the thesis in Section 3.5, I present the background to the authentic science context of studies II, III and IV, and to STSPs in particular.

3.1 Motivation theories
Motivation theories and motivation studies emerge from various theoretical perspectives, and motivation is frequently defined in ways that are similar Koball and Glynn’s (2007) definition: “an internal state that arouses, directs and sustains students’ behaviour” (p. 85). As an internal state, motivation cannot be observed directly, but must be studied through one or more other aspects that are perceived as being related to motivation. Much motivation research has been conducted in experimental settings, and not in highly complex contexts such as the school classroom. However, several motivation theories have been used to delimit motivating factors and explain outcomes in classroom settings. Three motivation theories are central to the conceptual framework used in Study I: Self-determination theory (SDT; 3.1.1), Achievement goal theory (3.1.2), and Expectancy value theory (3.1.3). Additionally, epistemological beliefs, used in Studies I and II, and attitudes used in Study II are introduced in Section 3.1.4. Together, these theoretical concepts provide the basis for the multi-theoretical approach applied in this thesis to understand students’ motivation and emotional experiences in the classroom.

3.1.1 Self-determination theory
SDT (Deci & Ryan, 1985; Ryan & Deci, 2000a) is used in a wide variety of disciplines, such as sports science, working life, medicine, parenting, and education. SDT is a humanistic theory based on the assumption that, as long as three basic psychological needs are fulfilled, people are active, curious and exploring.
The three basic needs that need to be fulfilled are feelings of competence, autonomy and relatedness (Ryan & Deci, 2000b). Students’ feelings of competence, autonomy and relatedness vary between contexts and can be enhanced by the teacher via teaching methods and classroom climate. For example, students’ feeling of competence can be increased by working with tasks that are challenging but not too difficult, and from relevant teacher feedback. Students’ feelings of autonomy can be enhanced by student-centred teaching methods that give students freedom to influence and take responsibility for their own learning. However, a student can also experience high autonomy during teacher-centred learning if the student clearly understands and accepts the purpose of the learning and work based on their own interest. Students’ feelings of relatedness can be increased by creating settings in which students feel safe and accepted in relation to their teacher and peers, and when they experience the social classroom context as open for questions and discussions. Experiencing high levels of competence, autonomy and relatedness makes a student more likely to be motivated intrinsically rather than extrinsically.

Intrinsic motivation is when a person acts because the value of the action is interesting, enjoyable, or in another way gives satisfaction. Extrinsic motivation is when a person acts to reach an extrinsic goal, for example earn a grade, please the teacher or avoid punishment (Ryan & Deci, 2000a). The qualitative difference between intrinsic and extrinsic motivation is central to SDT. Ryan and Decis’ theory also divides extrinsic motivation into sub-categories based on how autonomous the regulation of the actions is to the individual, see Figure 2.

The sub-categories of extrinsic motivation are based on how autonomous the regulation of action is perceived. Internalisation and integration are the processes by which reasons for actions are changed, from being external to being internal and autonomous. In a classroom context, the sub-categories of extrinsic motivation reflect to what extent a student value the learning and engage in learning for internal reasons. With increased degree of internalisation and integration, extrinsic motivation is divided into external regulation, introjected regulation, identified regulation and integrated regulation.

External regulation is when actions are performed to satisfy external demands, for example when a student works on a task, to get a reward or to avoid punishment. Introjected regulation is more internal than external regulation, but actions are still performed for external reasons. Examples are when a student works on a task to achieve feelings of pride when the task is completed or to avoid feeling of shame if the task is not done.
Identified regulation is when actions are considered important and the student has own control of the process, for example appreciates the results of working with a task and recognizes the value of the learning outcome. Finally, integrated regulation is the most autonomous type of extrinsic motivation. The action is fully integrated with the individual’s own will but the focus is still on the result of the action, which is the difference between integrated regulation and intrinsic motivation.

I will use SDT in different ways. Several variables from SDT (intrinsic motivation, identified regulation, introjected regulation, external regulation and perception of autonomy) are included in the conceptual framework used in Study I, and competence, autonomy and relatedness are central concepts in Studies III and IV.

3.1.2 Achievement goal theory
Achievement goal theory (Elliot & Covington, 2001) is a social-cognitive theory that focuses on how an individual’s goals, that is the reasons they have to engage in different learning activities, influence their achievements and experiences in different situations. A distinction is made between mastery goals and performance goals.

To simplify and describe the extremes, students with mastery goals focus on mastering a task and learning new skills. Mastery goals are often associated with a high quality of learning, a high degree of metacognition, perseverance and willingness to revise existing knowledge in the case of cognitive conflict (Ames, 1992; Pintrich & De Groot, 1990; Senko, Hulleman & Harackiewicz, 2011). Individuals with mastery goals tend to attribute the outcomes of learning to internal and controllable factors, such as knowledge and effort. Students with performance goals focus on performance and skills that are assessed in comparison with others and tend to link performance with self-value. As a result, students with performance goals may perceive learning situations as threatening and often experience anxiety and
nervousness associated with their own knowledge being exposed, such as when the teacher asks a question before the entire class. Surface strategies are often used to learn the content, which affects the quality of the knowledge.

According to Elliot and Murayama (2008), goal orientation has an additional dimension, approach- and avoidance goals. Both mastery and performance goals have this dimension, but I will only introduce the performance approach- and avoidance goals. The reasons for approach- and avoidance goals are mainly affective, and they concern whether the individual is striving to achieve something positive (approach goals) or to avoid something negative (avoidance goals). Students with avoidance goals have avoiding being worse than others as their primary goal. To protect their self-value and to be able to attribute failure to external factors rather than to themselves, these students sometimes use self-handicapping strategies, such as to forget to study for the test, show up late for class, and create disorder around them (Covington, 2000). Students with approach goals have achieving well as their primary goal. They are often self-confident and successful in school. They often attribute their success to internal, uncontrollable (but stable) factors such as innate intelligence or talent.

It is important to remember that goals are not personal characteristics, but a product of past learning experiences, highly open to influence and change. Tytler, Osborne, Williams, Tytler, & Cripps Clarke (2008) synthesized motivational and educational research, and concluded that an increased level of challenge, combined with opportunities for creative problem solving and constructive discussion in a learning situation, allows and sees failure as a necessary component of learning leading to a change in goal orientation from performance- to mastery goals, as well as to positive changes in in epistemological beliefs, attitudes and attributions.

Mastery and performance goals are included in the conceptual framework in Part A, and are used to select students who participated in Part B of this thesis (see Section 4.2.1).

3.1.3 Expectancy-value theory

Expectancy-value theory is a social cognitive theory, where expectancies, values and cost are important factors, and goals, expectations, intentions and self-efficacy are important influences on the factors extrinsic and intrinsic motivation.

There are several motivation theories that include expectancy and value, but the one most frequently used in educational settings is the expectancy-value theory developed by Eccles and Wigfield (Eccles et al., 1983; Eccles & Wigfield 2002; Wigfield & Eccles, 2000). According to the expectancy-value model, a student’s expectations about how successful she will be with the task and the perceived value of the task, are the two most
important factors for effort, persistence and results (Wigfield & Eccles, 2000).

Expectancy for success includes a person’s expectancy and beliefs about how successful the work will be, and the outcome of the task, will be. This expectancy can have a short-term or a long-term perspective (Wigfield & Eccles, 2000). Expectancies are developed from earlier experiences with similar tasks. They are also depend on the person’s attributions for success and failure, as well as the difficulty of the task compared to the perceived ability to perform the task. Task value includes various components: Attainment value refers to the importance of the task; Intrinsic value refers to how interesting the task is perceived by the person; Utility value is how useful the task or the outcome is to the person; and a fourth component is the cost in invested time and energy to perform the task. (Eccles et al., 1983; Wigfield & Eccles, 2000).

Utility value, attainment value, intrinsic value, expectancy of success and attributions for success and failure are incorporated into the conceptual framework in Part A.

3.1.4 Additional theoretical concepts
In addition to the theoretical concepts derived from SDT, achievement goal theory and expectancy-value theory, I use concepts related to epistemological beliefs (e.g. Hofer, 2004) and student attitudes towards science (e.g. Osborne, Simon & Collins, 2003; Saleh & Khine, 2011).

Epistemological beliefs are the beliefs a person holds about the nature of knowledge and knowing (Hofer, 2004). Hofer further divides the nature of knowledge into certainty of knowledge that describes if an absolute truth exists or if knowledge is dynamic and evolving, and simplicity of knowledge that describes if knowledge consists of unrelated facts or of a complex structure of interrelated concepts. She also divides Nature of knowing into source of knowledge, that describes if knowledge is learnt from external authorities (for example teachers) or constructed within the learner, and justification for knowing, that describes if knowledge is justified and evaluated based on observation, authority or what feels right, or on rules of inquiry and synthesis of previous knowledge. The four types of beliefs are described as dichotomies with the extremes as indicators; however, for all types of beliefs the distance between the extremes is great. Epistemological beliefs have previously been shown to be important for both learning and motivation (e.g. Bodin & Winberg, 2012; Bråten & Strömsö, 2006; Winberg & Berg, 2007), and the constructs certainty and simplicity were included in the conceptual framework and used in Studies I and II.

The term attitude is used broadly, both in educational contexts and in everyday life. One definition of attitudes is “feelings, beliefs and values held about an object” (Osborne, Simon & Collins, 2003, p. 1053), but researchers
such as Koballa and Glynn (2007) have pointed out that the term attitude is not used consistently, but is interchanged with other related terms, such as interest, value, opinion and motivation. From a wide range of attitude scales, three scales relevant for the school science context were seen as particularly relevant for use in study II. The three scales, self-concept, view of science and future participation in science, all derive from the work of Kind, Jones and Barmby (2007). Self-concept in science asks if students sees themselves as good or bad at science and regard science as easy or difficult. View of science (originally named learning science in school) asks if science is perceived as fun, boring and/or interesting. Finally, future participation in science draws on different aspects of future studies and future career in science.

3.2 Frameworks for motivation in the classroom
Research on motivation in science education has, like research of motivation in most other educational disciplines, relied heavily on quantitative evaluations of student self-reports, and these will be reviewed in 3.3. For the mixed-methods study in Part B, it was necessary to consider how motivation can and has been studied in the complexity of the classroom. This included both methodological and theoretical issues, and since few qualitative studies of motivation in science education have been published in the archived literature, I needed to draw upon work in other educational disciplines.

Fulmer and Frijters (2009) review methodological alternatives for studying motivation, and among other methodological alternatives they include a phenomenological/authentic approach. Here, motivation is not seen as a stable trait or a state, but as a process that takes place in, and depends on, the context. Further, Fulmer and Frijters (2009) discuss how authentic approaches to measuring motivation, using methods such as classroom observations, semi-structured interviews and case studies, can contribute to motivation research by providing knowledge about, for example, what students believe influence their motivation, relationship between motivation and actions, and relationship between what happens in classroom and student motivation.

Qualitative studies are sometimes accompanied by theoretical views of motivation complementary to the motivation theories presented. One way in which this view of motivation may differ is in the relationship between person and context. Most motivation theories rely on a cognitive view of motivation, where motivation is internal and individual, and the context as variables influencing the individual's motivation. According to Turner (2001), such a cognitive view of motivation focuses on either the individual or the learning environment, placing one in the foreground and the other in the background. Due to this limitation, she suggests a situative perspective
of learning (Lave & Wenger, 1991) and proposes a situative view of motivation that, rather than the individual- or learning environment dichotomy, put focus on the interaction between the two. From a situative perspective, motivation is seen as a social phenomenon, and this perspective opens for other approaches to study motivation based on participation and interaction.

The following sections present three frameworks that influenced and guided the mixed-methods study in Part B; the view of motivation as a dynamic and interactive process used by Dörnyei (see, for example, Dörnyei & Ushioda, 2011; Dörnyei & Ottó, 1998) and other researchers in the field of second-language learning (Dörnyei, MacIntyre & Henry, 2015), Hierarchical model of intrinsic and extrinsic motivation (HMIEM; Vallerand, 2000) and Brophy's framework about Motivation to learn (Lee & Brophy, 1996) that has been adapted to the science classroom by Andersen and Nielsen (2013).

3.2.1 Motivation as dynamic
Dörnyei and other researchers in the field of second-language learning have theorized motivation as a “complex dynamic system” and explored motivation in the classroom in ways that acknowledge motivation as a dynamic and interactive process. For example, they developed a process-model to study motivation in the classroom (Dörnyei & Ottó 1998, Dörnyei 2000). It differs from the other views of motivation by adding a clear time perspective and drawing on the dynamic aspects of motivation that ought not be neglected in a complex classroom environment. They describe their approach as “a situated and process-oriented account of motivation” that inevitably leads us to a dynamic conception of the notion of motivation that integrates the various factors related to the learner, the learning task and the learning environment into one complex system whose ultimate outcome can be seen as the regulator of learning behaviour (Dörnyei & Ushioda 2011, p. 89).

The time dimension divides the complex dynamic system into 3 stages; the pre-actional, the actional and the post-actional stage, see Figure 3.

The pre-actional stage involves setting goals, forming intentions and launching action before the actional stage, which represents the learning situation. The post-actional stage is retrospective and evaluating. This model provides a framework to relate individual motivation, such as goals and attitudes, to what happens in the complex dynamic classroom setting.

In the thesis I have used the process model of motivation for design and interpretation of the mixed-methods study in Part B, studies II, III and IV.
3.2.2 Hierarchical model of intrinsic and extrinsic motivation

HMIEM (Vallerand, 2000) does, like the process model Dörnyei (Dörnyei & Ottó 1998, Dörnyei 2000), take aspects of motivational dynamics into account. It builds on SDT and includes intrinsic and extrinsic motivation as well as acknowledging that intrinsic motivation is dependent of the fulfilment of the three basic needs – competence, autonomy and relatedness. The contribution of the model is that it divides motivation into three different levels of generality. Global motivation is the first and most general level. Global motivation refers to a person’s general motivation tendencies when they engage in an activity and interact with their environment (Lavinge & Vallerand, 2010). Contextual motivation is the second and intermediate level, and refers to a person’s motivation towards a specific domain such as science. Situational motivation is the most specific level, and represents motivation here and now in the specific current situation, for example in a specific science lesson. A picture overviewing this model can be seen in study IV in this thesis. In study IV I also bring forward that:

Lavinge and Vallerand (2010) also suggest interaction between the different levels of generality, both in terms of top-down and bottom-up (recursive) effects. For example, with high levels of intrinsic/self-determined contextual motivation for science, it is likely that a student has high level of situational motivation in a specific science lesson. Further, repeated experiences of high situational motivation in a science lesson can similarly be hypothesised to lead to more intrinsic/self-determined contextual motivation in the school science domain. Further, at each level in the model it is stated that background factors, mediated through competence, autonomy and relatedness, lead to motivation that has consequences of affective, cognitive and behavioural characters. (Study IV, p. 4)
HMIEM highlights the idea that what happens in a particular situation, like in a specific science lesson, or in a series of science lessons, such as the Medicine Hunt (situational motivation) can influence motivation in a broader sense, in this case, motivation for science in general (contextual motivation). The idea of recursive effects is incorporated in study II.

3.2.3 Motivation to learn

Brophy's (2004) term motivation to learn focuses on how teachers can stimulate students to see value and meaning in learning activities. This includes providing opportunities to learn, challenging students' thinking, and formulating evaluations that help students take different directions in their thinking (Andersen & Nielsen, 2013). Lee and Brophy (1996) argue that the framework “integrates issues of motivational operations and learning processes within the context of academic activities in classrooms” (p. 304) and Andersen and Nielsen argue that it “offers a synergy between theories of motivation and classroom discourse and interaction, and shifts the focus slightly to observable features” (p. 910).

Andersen and Nielsen (2013) base their research in Brophy's (2004) framework about students' motivation to learn as well as in self-determination theory and self-efficacy. They developed and tested a framework for video-based analysis of motivation and interaction in the science classroom that consists of (a) students' actions and engagement (for example content of talk and engagement), (b) teachers' actions, questions, and responses (autonomy supporting or controlling teacher), and (c) approach to subject matter (including communicative approach used and content perspective). Andersen and Nielsen conclude that students' motivation to learn in the science classroom is influenced both by interactions in the classroom and the teachers' approach to science content. However, like Lee and Brophy (1996), they argue that more research in this area is needed.

Andersen and Nielsen (2013) and the framework about Motivation to learn influenced what teacher and student factors to consider and observe in the classroom in Study IV.

3.3 Motivation in science education

Potvin and Hasni (2014) reviewed research on students' interest, motivation and attitudes in science education from 2000 to 2012. Of the 228 papers their systematic literature search found, 63 referred to interest, 121 to attitudes, and only 49 to motivation. Of the papers about motivation, most “included the idea of a ‘goal’ [...] that oriented behaviour” (p. 94). Further, internal processes were more frequently studied than external influences. Potvin and Hasni also highlight the balance between quantitative and
qualitative studies. When combining studies of interest, motivation and attitudes, 189 studies were based on questionnaires, 16 were interview studies and only three were based on classroom observations. It is not clear how many of the 16 interview studies and how many of the 3 observation studies concern motivation, yet the low number of studies indicates more research is needed to understand the processes behind, and effects of motivation in science education. Part B of thesis provides such a contribution.

It is, however, clear that research in science education, as well as in other disciplines, has shown that motivation is important for learning and achievement (e.g. Areepattamannil, Freeman & Klinger, 2011) and for career-related choices (e.g. Bryan, Glynn & Kittleson, 2011; Taskinen, Schütte & Prenzel, 2013), and that classroom-factors can influence students’ motivation (e.g. Kiemer, Groschner & Pehmer, 2015; Potvin & Hasni, 2014). The following sections give an overview of research in motivation in science education, divided into studies that view motivation as a background factor for learning and choices (section 3.3.1), and studies that view motivation as an effect/outcome of activities (3.3.2). Studies that treat motivation as a background factor aim to learn more about, for example, how student motivation affects learning and achievement and what role motivation has for choices of studies or career, whereas studies that treat motivation as an outcome aim to find out, for example, how motivation is affected by teachers or classroom activities.

### 3.3.1 Effects of motivation

Learning and achievement is supported by, or related to, motivation through, among other things, intrinsic motivation (Areepattamannil, Freeman & Klinger, 2011), mastery-goal orientation (Patrick & Yoon, 2004), self-efficacy (Bryan, Glynn & Kittleson, 2011; Zusho, Pintrich & Coppola, 2003), and task value (Zusho, Pintrich & Coppola, 2003). This suggests that students with intrinsic motivation, mastery goals, high self-efficacy and who see high value in science tasks learn and achieve more in science. Areepattamannil, Freeman and Klinger (2011) showed that extrinsic motivation has no effect on science achievement and that student-level factors were better predictors of science achievement than school-level factors. Zusho, Pintrich and Coppola (2003) demonstrated that self-efficacy, together with perceived task value, are the best predictors of chemistry course performance and suggest that teachers can encourage students’ self-efficacy by focusing on the role of effort and the use of strategies in studying and learning chemistry. Further, they suggest that teachers can support students’ perceptions of task value in their teaching by focusing on how chemistry relates to everyday life. Patrick and Yoon (2004) used a qualitative approach and achievement goal theory for a classroom-observation study, in
which where they found qualitative differences in students’ types of motivation and in students’ nature of thinking. The differences were, for example, terms of thoughtfulness and development of conceptual understanding. The results indicated that a mastery-goal orientation is favourable and more related to conceptual understanding than a performance-goal orientation.

Students’ choice of science-related careers is related to motivation through among other things students’ interest and self-concept in science (Taskinen, Schütte & Prenzel, 2013) and through instrumental goal orientation, past grades, and social support for science (Koul, Lerdpornkulrat & Chantara, 2011). Further, Bryan, Glynn and Kittleson (2011) who studied motivation differences between students who planned to enrol in advanced placement program science courses and those who did not found that intrinsic motivation, self-efficacy, and self-determination were significantly higher for the group that planned to enrol in the courses. Based on these results, they suggested that teachers discuss motivation for science with students in order to make students more aware that not only skills, but also motivation, is important for career-related choices.

3.3.2 Reasons for motivation
Reasons for motivation, or — how can we increase student motivation? — is an important question for researchers and science teachers. Factors at the school level have been shown important for student motivation (Fortus & Vedder-Weiss, 2014; Taskinen, Schütte & Prenzel, 2013; Vedder-Weiss & Fortus, 2011), yet research has mainly concerned motivating factors at the classroom level. With an open approach based on student essays and interviews, Bryan, Glynn and Kittleson (2011) investigated what motivates students, and concluded that three strong motivators were inspiring teachers, career interests, and collaborative learning activities. However, most other studies examine how specific factors motivate students in science; for example, teaching-student interaction, collaborative, authentic and hands-on learning, and the science topic.

A teacher-professional development intervention focussing on improving classroom discourse and verbal teacher-student interactions that was studied by Kiemer, Groschner and Pehmer (2015) found teachers’ ways of interacting with students through questions and feedback showed positive changes along with positive changes in student motivation.

Aspects of collaborative, authentic and hands-on learning activities were shown to be important in two studies using an open approach to asking what classroom factors motivate students (Bryan, Glynn & Kittleson, 2011; Velayutham & Aldrige, 2013). When collaborative, authentic and hands-on learning were studied in relation to student motivation for science (e.g. Gerstner & Bogner, 2010; Milner, Templin & Czerniak, 2011; Shachar &
Fischer, 2004), results are mixed. Milner Templin and Czerniak (2011) investigated student motivation in two different learning environments, the authentic life science laboratory, and the traditional classroom. Their results indicated that students were more often motivated in the life science laboratory than in the traditional classroom, but that students appreciated and valued these classrooms in different ways. On the contrary, Gerstner and Bogner (2010), found no difference in intrinsic motivation or knowledge between students using a hands-on instruction compared to students using a teacher-centred approach, and Shachar and Fischer (2004) showed that students scored significantly lower on both motivation and knowledge after a group investigation/cooperative learning method compared to a control group. In their review, Potvin and Hasni (2014) suggest that inquiry-based learning, but not activities that are only hands-on, favours interest, motivation and attitudes.

The science topic has been shown to be central to students’ motivation (e.g. Bathgate, Schunn & Correnti, 2014; Nieswandt & Shanahan, 2008). Students may not perceive “science” or “chemistry” or “physics” the primary motivating unit, but rather may be much more motivated in relation to some specific topics than to others. In the study by Nieswandt and Shanahan (2008), the key task characteristic was relevance — students’ motivation was more intrinsic when they engaged in topics that were relevant to them. Connecting school science to real-life applications was also found to be important for students’ interest in science and science self-concept in a study conducted by Taskinen, Schütte and Prenzel (2013). Bathgate, Schunn and Correnti (2014), on the other hand, who investigated how fifth- and sixth grade students’ motivation for science varied across context, manner of interaction, and topic showed that science topic was more important for student motivation than both context and manner of interaction.

In sum, the literature on motivation in science education supports the idea that authentic tasks, including aspects such as inquiry and contextualised research problems, have the potential to play a role in supporting students' motivation for science.

3.4 School science meets authentic science
The authentic science tasks studied in this thesis are a part of a student-teacher-scientist partnership (STSP) called the Medicine Hunt (for details, see section 4.2.2). It serves as an example of how school science meets authentic science, a meeting that can be both difficult and rewarding.

In 2009, Hsu and Roth highlighted differences between school science and authentic science by looking at what teachers say to students about authentic science. More specifically, Hsu and Roth investigated the discursive resources teachers draw on when they introduce students to
authentic science before and during out-of-school learning activities. The discursive resources used were a) science is special by including special skills, materials and environments, b) scientists are ordinary people, c) teacher is genuinely enthusiastic about science, d) science is relevant for daily life, e) science is empirical and hands-on activities are positive, and f) it is rare to get first hand opportunities of authentic science. Drawing on those resources, the teacher explicitly and implicitly promoted authentic science to the students in the classroom at the same time as the resources, from a school perspective, summarise potential differences between school science and authentic science.

Several researchers discuss the difficulties with making school science more authentic (e.g. Braund & Reiss, 2006; Rahm, Miller, Hartley & Moore, 2003; Quigley, 2013) and reasons why it is not a simple thing to merge the two. Quigley (2013) describes the challenge with the alignment of two cultures, science and school, and claims that the result often is not a hybrid between the two, but rather activities that scientists “would not participate in nor endorse” (p. 116). Rahm, Miller, Hartley and Moore (2003) argue that authentic science cannot be taught in traditional didactic modes or through simulations in the classroom, as it is something that is gradually created in interaction between students, teachers and scientists and therefore takes time and requires a context for interaction. Braund and Reiss (2006) discuss the role of the traditional school science classroom and argue that, even if it has its advantages, it restricts what can be taught and learnt. They suggest out-of-school learning activities, such as field trips or visits to science centres, science museums, botanic gardens and zoos. This they suggest because those contexts can contribute to, for example, better attitudes to school science, opportunities for practical work, improved understanding and integration of concepts and opportunities for collaborative work. Rahm, Miller, Hartley and Moore (2003) and Braund and Reiss (2006), thus, agree that authentic science cannot simply be introduced in the classroom. Rather, they see different requirements for a successful synthesis. Requirements for a successful synthesis will be addressed further in the specific case of STSPs in Section 3.4.1.

Many studies have shown that if authentic science is introduced in a good way it can have positive effects on both affective outcomes and learning outcomes (see Sadler, Burgin, McKinney & Ponjuan, 2010 for review). Regarding affective outcomes, Potvin & Hasni (2014) concluded that inquiry-based learning (but not activities that are only hands-on) favours interest, motivation and attitudes, and that contextualisation of the science content seem to have positively links to students’ interest. These conclusions are based on a review of recent research on student interest, motivation and attitudes towards science. Inquiry based learning and contextualisation are central in the four components of authentic learning proposed by Rule
(2006): connection to real world problems, open-ended inquiry including thinking skills and metacognition, student participation in a social learning community, and finally, that learning is student-centred and students can make their own choices during learning. At the same time, students often experience ordinary school science as decontextualized, difficult and taught with transmissive pedagogy (Lyons, 2006). Therefore, one can hypothesize that science education inquiry and contextualisation could be improved through authentic science.

3.4.1 Student-teacher-scientist partnerships and similar projects
There have been many projects where school science and authentic science have met, and students have been introduced to authentic science in various ways. For example, through visits to science centres, science museums, botanic gardens and zoos as suggested by Braund and Reiss (2006), through longer projects within schools, or in collaborations with universities. Such projects are, depending on their foci, referred to for example as research apprenticeships, which is a broad term, or as student-scientist partnerships (SSPs) or student-teacher-scientist partnerships (STSPs) (Sadler, Burgin, McKinney & Ponjuan, 2010) if they include collaboration between scientists and school classes. Many of the research apprenticeships are arranged as extra-curricular programmes, for example as summer schools to which students with special interest in science can apply and selection is often based on previous achievements in science. This is criticised by, for example, Quigley (2013), who argues for the importance of giving all students, and not only those with a special interest or talent for science, opportunities to engage in the authentic inquiry. SSPs and STSPs take place within the curriculum as a part of ordinary teaching and also include students without previous special interests in or skills for science. In this way they provide opportunities to make more students interested in science.

Houseal (2010) define STSPs as “partnerships in which students, teachers, and scientists work together to answer real-world questions about a phenomenon or problem the scientist is studying”. Examples are the GLOBE programme (Global Learning and Observations to Benefit the Environment; e.g. Castro Rojas, Acuña Zuniga & Fonseca Ugalde, 2015; Means, 1998) where students in different locations in the world for example register atmospheric data, the Forest Watch (Fougere, 1998; Rock & Lauten, 1996) where growth of pine trees in longitudinally studied by students, and STaRRS (Students, Teachers, and Rangers & Research Scientists: Investigating Earth Systems at Mammoth Hot Springs; Houseal, 2010; Houseal, Abd-El-Khalick & Destefano, 2014). These and similar projects give students opportunities to be important partners in authentic research and learn from researchers, while researchers get valuable help with collection of sampled materials, for example from a wide range of geographical locations.
Houseal Abd-El-Khalick and Destefano (2014) makes recommendations for the structure and implementation of a successful partnership. These include, involve all participants in design and activities of the project, have a third party liaison familiar with both school and research, have continuous communication between students, teachers and scientists, and build long-term relationships. They also suggest that the power balance between students, teachers and scientists is carefully considered. Finally, they highlight need for special attention to be paid to two key aspects: data quality and selection of research questions. With a considered development and implementation strategy, a successful project has potential to give students opportunities to work inquiry-based, follow different steps in a research-process and be guided by authentic research questions.

3.4.2 Outcomes of student-teacher-scientist partnerships

It has been shown that both teachers and students can gain from participating in STSPs. It can, therefore, also be hypothesised that the teacher partially influences students’ experiences and outcomes if s/he mediates parts of the science content and implementation of activities.

Houseal, Abd-El-Khalick and Destefano (2014) and Caton, Brewer and Brown (2000) report positive outcomes for teachers after participation in partnerships with scientists. Houseal, Abd-El-Khalick and Destefano (2014) found that teachers gained more positive views about science and scientists and shifted their pedagogical choices after participating in an STSP, and Caton, Brewer and Brown (2000) reported that teachers feel greater confidence in teaching using inquiry after participating in a partnership with scientists. The greatest obstacle for the latter project was the teachers’ lack of time (Caton, Brewer & Brown, 2000). Based on these results and the suggestions for successful partnerships proposed by Houseal, Abd-El-Khalick and Destefano (2014), it can be concluded that time, good communication between teachers and scientists, and teachers’ confidence are important for the teachers’ role in such a partnership.

Student outcomes of STSP projects have been evaluated using for example self-reports, interviews, journal entries, and scientific presentations. These evaluations report both positive and less positive outcomes for learning gains, better student attitudes towards science and scientists, and affective factors, such as enjoyment and pride in participating in authentic research. For example, Houseal, Abd-El-Khalick and Destefano (2014) reported learning gains from an STSP; students in the intervention-group (participating in the STSP) gained better content knowledge than a comparison-group. In an earlier study, Wurstner, Herr, Andrews and Alley (1998) reported that students, when presenting their results to scientists, showed understanding of scientific concepts, could apply them, reason and draw conclusions about the research studies they had made in the
partnership. Moss, Abrams and Kull (1998), however, on the basis of a longitudinal interview study, found that students’ conceptual understanding of scientific research rarely changed over the year the STSP they were investigating, and that students gained little experience of communicating science. The impact of STSPs on positive attitudes has been studied by, among others, Paris, Yambor and Packard (1998) and Houseal, Abd-El-Khalick and Destefano (2014). Houseal, Abd-El-Khalick and Destefano found increased positive student attitudes towards scientists after their participation in an STSP, yet they also found that student attitudes to scientific inquiry and enjoyment of science lessons remained unchanged. Paris, Yambor and Packard used a single scale with 16 items including both informal and formal science settings and, as a whole, students attitudes were more positive after the STSP. Affective factors shown to be important in relation to STSPs include believing that the data collected is of importance (Means, 1998), getting students more excited about science (Fougere, 1998), and giving the students a feeling of pride and usefulness (Fougere, 1998). The mixed results for students’ outcomes in relation to STSPs make it clear that more research is needed to understand the details of what is needed for a successful partnership. The complexity of the STSP requires a research approach that can investigate and take into account the many aspects of implementation and the diverse outcomes of the STSP; the mixed-methods approach used in the thesis is one way this can be achieved.

3.5 Summary
Motivation theories and constructs from theories of beliefs and attitudes serve as a theoretical framework for the work in this thesis. Motivation theories and quantitative methodologies have dominated previous research on motivation in science education. For example, research has shown that teachers, classroom practices and the particular science topic are important for student motivation and that many aspects of motivation, for example intrinsic motivation and self-efficacy, are related to students learning and achievement in science as well as to choices of science-related careers. Thus, there are several reasons to keep students’ motivation high. At the same time there are few qualitative studies of motivation in the science classroom, or where students express their motivation for science in their own words. This limits our understanding of motivation in science education.

In other disciplines, for example mathematics and second-language learning, other theoretical approaches to motivation have been explored in greater detail. These approaches give students’ experiences and the classroom context more important roles and have the potential to increase the understanding of motivation as dynamic and interactive.
The context for this thesis is a project where authentic science is introduced in school; secondary school classes work together with researchers in a STSP. To introduce authentic projects in school can be both difficult and rewarding, and successful STSPs have shown positive outcomes in terms of, for example, student learning gains, better attitudes towards science and scientists, and feeling enjoyment and pride from participating in authentic research. In addition to the positive outcomes, authentic projects also have potential to support teachers and students in their work towards the Swedish national curriculum’s subject-specific and long-term goals for science. However, research results about authentic projects in school are mixed and indicate that projects including reflection and inquiry have better outcomes than those that only provide opportunities for hands-on work. Given these mixed research findings, using a combination of quantitative and qualitative methods to provide an understanding of how students’ motivation, experiences and engagement are connected when they work with an authentic approach to science, is a prudent and well-motivated choice that will allow this thesis to demonstrate in a nuanced way how authentic science influences students’ motivation for their school science studies.
4. Research design & methods

The four studies in this thesis are based on the two-part research design shown in Figure 4. Part A is a large-scale questionnaire study in mathematics that served as the basis for a selection of personal motivation-related factors for investigation in Part B. The results of this questionnaire study are presented in Study I. Part B is a mixed-methods study of students participating in the STSP the Medicine Hunt. The results of the mixed-methods study are presented in studies II, III and IV. The workflow in the thesis is shown in Figure 4, and consisted of the following five steps:

1. A large number of personal (motivation-related) factors and situational factors were extracted from motivation theories, and from theories of beliefs and emotions. Those factors were included in two questionnaires used to evaluate which were most important personal and situational factors for student motivation and positive emotions.

2. The most important personal factors and situational factors for students’ positive activating emotions were evaluated and reported in Study I.

3. The most important personal factors were used in a mixed-methods design to study student motivation in the science classroom. Additional perspectives on motivation in the classroom were added to study student opportunities for motivation in the science classroom, students’ actions in the classroom and students’ experiences of authentic science. The context was an STSP where students worked with an authentic research project.

4. A mixed-methods study with questionnaires, interviews and video observations was performed. Results from questionnaires, interviews and video observations were analysed separately and reported in Studies II-IV.

5. Data from the different studies will be merged and I discuss the studies outcomes in terms of: (1) the classroom factors that are important for students’ motivation and positive experiences, and (2) how students work with, and how do they experience working with an authentic approach to science. Having discussed these, they are synthesised to address the overall purpose of the thesis: How an authentic approach can contribute to students’ motivation for school science.
Figure 4. Overview of the workflow in the thesis, showing theoretical aspects, instruments used, and how the four studies are linked. Step 5 above, how data is merged, is not shown in this figure.

The research design and methods of Part A: Predicting motivation (4.1) and Part B: Students as scientists (4.2) are introduced separately, and followed by the methods by which results form the different studies are combined (4.3) and ethical considerations (4.4).
4.1 Part A: Predicting motivation
In order to find out which factors are important for student motivation in mathematics, a two-part questionnaire was developed. The development took its starting point in the motivation theories self-determination theory, achievement goal theory and expectancy-value theory, and in theories of epistemological beliefs and emotions. The following sections describe the conceptual framework, the context in which the study was performed, and the participants, instruments, and procedure. Data analysis is presented in detail in Study I.

4.1.1 Conceptual framework
The conceptual framework is based on a group of personal motivation-related factors and a group of situational factors known to influence motivation and emotional experiences. An overview is given in Figure 5. How the variables were selected, how they are related, and each variable's theoretical origin is described in detail in Study I.

4.1.2 Context
The data was collected in collaboration with the Swedish Schools Inspectorate as a motivation sub-study of an quality-evaluation of upper secondary school mathematics in Swedish schools.
The aim of the evaluation was to assess goal-fulfilment and performance in mathematics, and the specific aim of the motivation sub-study was to find personal and situational variables important for student motivation and learning, and to evaluate what level students “scored” on different personal and situational variables in Swedish classrooms (Palm, Hellgren & Winberg, 2010). The motivation sub-study was published in the report “Svenska gymnasieelevers motivation i matematik” [Swedish upper secondary school students’ motivation for mathematics] (Palm, Hellgren & Winberg, 2010) and in Study I (Winberg, Hellgren & Palm, 2014). The context was the ordinary mathematics classrooms; to capture as much variation as possible in learning situations, the teachers in the study were asked to choose a lesson after which they handed out the questionnaires.

4.1.3 Participants, instruments and procedure
The participants in the study were 668 (341 girls, 323 boys and four who did not provide an answer to the question) first-year upper secondary school students from 33 Swedish schools.

The participants answered two questionnaires in relation to lessons in the school subject mathematics. The first questionnaire asks about how students see themselves in relation to, and how they experience the school subject. It covers students’ personal characteristics, e.g., beliefs about themselves and about learning the particular school subject in the study, as well as the general characteristics of the learning situation in the subject. After a second lesson in mathematics, the second questionnaire was completed. This questionnaire measures the characteristics of the specific learning situation and the student’s responses to it, in terms of behaviour, emotions and cognition. Multivariate models to predict students’ positive activating emotions were computed using partial least squares (PLS) modelling. Questionnaires, procedure, validation procedure and data analysis are described in detail in Study I, and the questionnaires are found in Appendix A and B. The results from Part A serve two purposes in this thesis. One, they form the basis of the discussion of question (1): What classroom factors are important for students’ motivation and positive experiences? and two, the personal factors shown to be most important for students’ positive activating emotions were included in the design of Part B.

4.2 Part B: Students as scientists
In order to learn more about how students work with and experience working with an authentic approach to science, and how this influences their motivation, a mixed methods study with questionnaires, interviews and video-observations was designed. The following sections describe the study design, the context in which the study was conducted, the participants,
procedure and instruments, and how data for the different studies were selected.

4.2.1 Design
Mixed methods methodologies have the advantage of not being limited by a particular method choice but methods can be selected and combined based on the questions the research aims to answer. Johnson and Onwuegbuzie (2004) argue that when using mixed-methods, researchers “should collect multiple data using different strategies, approaches, and methods in such a way that the resulting mixture or combination is likely to result in complementary strengths and non-overlapping weaknesses” (p. 18). In my studies, a mixed methods design was selected to explore the phenomenon of authentic science in the classroom by looking at it in different ways. The first way was a quantitative part with focus on how students’ motivation and related factors change during the time they work with the STSP. The second way was through students’ experiences of working with the STSP in their own words. The third was to look at what opportunities were given to the students in the classroom situations. These three ways give complementary views by taking into account students motivation, students’ experiences and classroom opportunities of authentic science in the classroom, see Figure 6.

![Diagram of Design](image)

Figure 6. Design of Part B. Pre-action: Activities (shaded) are not included in the study. Activities can be affected by personal variables; those listed were included in the questionnaire. Action: Actions included in the study are shown. Those can be affected by classroom factors, here listed as opportunities. Both groups are identified by observation. Post-action: Includes students’ experiences identified in the interviews. No other aspects were included (shaded).
The design was based on the personal variables most important for students’ positive emotional experiences in Part A. The initial questionnaire in Part B uses ten personal motivational variables, and the second interview- and video observation part uses the four most important personal motivational variables; intrinsic and extrinsic motivation and mastery and performance goals, for selection of students.

Situational variables in Part B were retrieved from the material with an exploratory analytical approach, and an overview of the groups of variables used is shown in Figure 6. The variables reflecting students’ experiences came from both experiences in immediate association to one lesson and experiences of the STSP-project. The variables reflecting classroom opportunities for motivation and student actions came from the video observations.

4.2.2 Context
Help a Scientist was initiated by The Nobel Museum in Stockholm as a strategic initiative to raise secondary school children’s interest in science and to act as a bridge between schools and university research. In Help a Scientist, students and their teachers collaborate with scientists in projects inspired by former Nobel Prize discoveries and closely linked to authentic current problems in research and society. Help a scientist was designed to be a part of the secondary school curriculum so that students would work with their usual science teacher in their own classrooms. The first project started in 2011, and is the context for the research presented in this thesis. The 2011 project was called the Medicine Hunt and was run in collaboration with a research group form Laboratories for Chemical Biology, Umeå (LCBU) at Umeå University. The project is described in detail by Lindberg, Hellgren, Lindqvist Forsberg, Almqvist, and Nordqvist (2014).

The scientific aim of the Medicine Hunt was to collect soil samples from different parts of Sweden and analyse them for secondary metabolites produced by the bacterial group actinomycetes. Secondary metabolites from actinomycetes can have anti-bacterial effects and may serve as future antibiotics. The Nobel museum and researchers at LCBU had seen that with help from secondary school students all over Sweden it would be possible to explore the Nordic forests for milieus where actinomycetes thrive. Based on geographical location and the teachers’ applications to participate in The Medicine Hunt that among other things described their school, 18 secondary school classes in years 7 and 8 (age 13-14 years) were selected to participate in the Medicine Hunt.

In early May 2011, the Nobel Museum and LCBU team gathered the teachers from the selected classes for an introductory conference where they learnt about the scientific and historical background of the topic, in what
type of habitats actinomycetes potentially could be found, and they were
given a timeline and instructions for the classroom laboratory work.

The classroom work consisted of a chain of steps, including selection of
a location, collection of soil samples, isolation of the bacteria,
characterization of the bacteria, and reporting of the findings to
the scientists via web-based forms. Students selected location for soil sampling
based on information and discussion about the types of soils actinomycetes
thrive in, together with their expert-knowledge of their local area. That
students made their own choices of sampling locations created opportunities
for feelings of ownership of the samples and potential future findings. The
students worked in pairs and collected duplicate soil samples; one sample
was sent to the scientists and the other was used for students’ work in
school. The students also kept a protocol of GPS-locations, habitat types and
habitat descriptions, and reported these to the researchers. Observation and
keeping protocols are important in scientific method and in scientists’ work;
here the responsibility fell to the students, potentially enhancing the
students’ experience of authenticity and ownership.

Isolation of bacteria from soil samples was a multi-step procedure that
took place during four lessons over a period of three–five weeks. First, the
soil was pulverized with calcium carbonate to select for actinomycetes, then
samples were spread on growth medium and incubated, and finally the
bacterial colonies were morphologically analysed. The results of the analysis
were reported in web-based forms directly to the scientists. The isolation
process was designed to be as authentic as possible, and students gained
opportunities to make observations, categorize observations and draw
conclusions from their own findings. Students reported their final findings
by making scientific posters of their results. In this way they got
opportunities to summarize, conclude, reflect and communicate their work
in a way that is common in the scientific community, for example at
scientific conferences.

4.2.3 Participants, procedure and instruments
All participants were students taking part in the Medicine Hunt. They were
enrolled in grades 7 and 8, and at this age (13-15 years) science is
compulsory in Sweden for all students. In the quantitative part of the study,
388 students (177 girls, 194 boys and 17 who did not respond to the
question) from 18 school classes participated. In the qualitative part of the
study, 24 students (15 girls and 9 boys) participated in Study III, and 12
students (5 girls and 7 boys) participated in Study IV. The selection process
is described in detail in section 4.2.4.
Data was collected at three different time points. Before starting the Medicine Hunt (May 2011), students answered questionnaires about their motivation, goals, values, beliefs and attitudes related to school science. During the lesson in which students analysed and identified bacterial colonies and reported their results to the scientists (October 2011) the video observations and audio recordings took place. The interviews were made immediately after this lesson. Finally, after the project had ended (November 2011) students answered the post-questionnaire about their motivation, goals, values, beliefs and attitudes related to school science.

Teachers distributed questionnaires to the students during a science class and the questionnaires were completed in the classroom. The teachers sent the questionnaires back to the researchers for analysis. The same procedure was used for the pre- and post-questionnaires.

The video-observations and interviews were made during a researchers-visit to the schools and classrooms. Before the lesson, a camera was placed in the front of the classroom, overviewing activity and movement. The observed students, the teachers and the scientist were equipped with mp3-recorders. Immediately after the video recorded lesson, the same students, who were recorded during the lesson, were interviewed about their experiences of the lesson and the Medicine Hunt.

The questionnaire used in Part B (see Appendix C) contained 63 questions. Forty-one represented 10 constructs reflecting different affective factors related to motivation: intrinsic motivation (4 items), extrinsic motivation (3 items), mastery goals (3 items), performance goals (4 items), utility value (4 items), epistemological beliefs certainty (3 items), epistemological beliefs simplicity (6 items), self-concept in science (5 items), view of science (4 items), and future participation in science (5 items). Twenty-two items represented constructs reflecting students’ experiences of their classroom situation in science: practical work in science (7 items), teacher enthusiasm for science (3 items), teacher support (6 items) and autonomy support (6 items). Most of the constructs were selected since they were identified as important for predicting positive activating emotions in the classroom in Study I. All questions had the form of a statement and were answered on five-point Likert-scales ranging from “strongly disagree” to “strongly agree”. Analysis of the results is described in detail in Study II.

The interviews were semi-structured and the interview guide is found in Appendix D. The interview focus was students’ experiences of participating in the project and in the specific lesson that immediately preceded the interview. The categories for analysis of the interview answers were derived from the material, and this process, as well as data analysis, are described in detail in Study III.

Video observations were analysed with a conceptual framework based on self-determination theory (Ryan & Deci 2000a, b), Vallerands HMIEM
(2000) and Dörnyei’s (2000) process model of motivation. This framework and the analysis of the video observations are described in detail in Study IV.

4.2.4 Selection of students and data for the studies

Data collection for Part B was extensive, and therefore strategic choices were made about which data to analyse and include in the studies reported in this thesis. I will now explain the choices I made in relation to first, the classes visited for data collection, second, the students to focus on, and third, the data for studies II, III and IV.

The participants in Study II were all 388 students taking part in the Medicine Hunt, in Study III they were 24 students, a sub-group of Study II’s 388 students, and in Study IV they were 12 students, a sub-group of Study III’s 24 students.

First, selection of classes for data collection for Studies III and IV was made based on the quantitative data in Study II. The criterion for the possible inclusion was that the class should include students with different motivation focus, in terms of intrinsic and extrinsic motivation and mastery and performance goals. A PCA model based on the four constructs and all 388 students was created, and the model generated two components, see Figure 7. Component 1 describes intrinsic motivation/identified regulation and mastery goals. Component 2 describes external/introjected regulation and performance goals. Classes that included students with different motivation focus were contacted and three of the teachers who were positive towards a visit and who were in similar phases of the work with the Medicine Hunt were selected for the study.

Second, the students to focus on in particular were selected from the PCA model. For example, from Study IV, we know student 133, to the right just above the middle in Figure 7 is Eric from Beth’s classroom, and that he is a student with high intrinsic motivation (c1) and intermediate extrinsic motivation (c2). Another student that can easily be found in Figure 7 is Frida from Christine’s classroom, student 272, in the bottom right-hand corner. Frida in Study IV is defined as a student with high intrinsic motivation (c1) and low extrinsic motivation (c2). Finally, Frank from Christine’s classroom, student 284, is found high up in the figure, just to the right of centre. Thus, on the basis of the PCA model, three classes that included students with various intrinsic and extrinsic motivation and mastery and performance goals were selected from the 18 classes in the Medicine Hunt, and eight students with various motivation focus in each class were selected from the PCA model. These 24 students were the sample for the interview- and observation studies.
Figure 7. PCA model for all students participating in the Medicine Hunt. Component 1 describes intrinsic/identified motivation and mastery goals. Component 2 describes external/introjected regulation and performance goals. Each student is represented by a number, and their position indicates their motivational orientation.

For Study IV that includes the analysis of the audio- and video recordings, four recordings from each class were selected for in depth and detailed analysis and it was necessary to among other things be able to clearly see the students’ actions on the video recording, and for the students to have returned the post-questionnaire. The selection of students inclusion in Study IV was based, therefore, on the following criteria in order of application: 1) the dataset (pre- and post questionnaire, interview, lesson recording) should be complete, 2) the students’ classroom actions should be visible on the video recording, 3) both boys and girls should be represented in each class and 4) variation in students’ intrinsic and extrinsic motivation should remain, as far as possible, in each class.

Third, when planning Studies II, III and IV, the research questions of each study guided what data was included in each study. For Study II, all items from the questionnaire referring to personal/individual/contextual motivation were used, and the ones referring to perception of classroom situations were excluded. For study III, the open questions about how the lesson and the project were perceived and why, were selected from the interviews and analysed. For study IV, audio recordings from the four students in each class were selected for analysis of students’ initiatives, group work and outcomes in the three different classrooms.
4.3 How results from the studies were aligned

To align the studies in the thesis, it is valuable to discuss results from the studies in relation to each other. Therefore, apart from the purpose, two specific areas for discussion are considered. The areas are:

(1) What classroom factors are important for students’ motivation and positive experiences? Study I and Study III will contribute to discussion of this question, and SDT is used as a framework to organise the discussion.

(2) How do students work with, and how do they experience working with an authentic approach to science? Results from Studies II, III and IV will contribute to this discussion, and the simplified process model of motivation after Dörnyei (2001) shown in Figure 3 and Figure 6 are used as a framework to organise the discussion.

4.4 Ethical considerations

Guidelines for research (Vetenskapsrådet, 2002; 2011) were followed and special attention was paid to a) information about the research project and use of data, b) confidentiality and c) consent.

Regarding the questionnaire studies, all information was communicated and distributed via written documents; students and parents were informed via teachers, during lessons (students), and written documents (parents). Teachers, students and parents were informed about the research project and use of data, confidentiality and consent. Information about the research project included that the focus was to learn more about students’ thoughts about the school subject; for example about the value of learning subject, how students feel about lessons, and what goals students have with their studies in the subject. Information also included that the research was done in order to understand what a good lesson looks like, and whether the perception of a good lesson varies between students. Information about confidentiality included how questionnaires would be handled, for example that no individual students or classes can be identified in the final reporting. The study included matching of two questionnaires, and a coding system for the questionnaires was, therefore, developed to avoid teachers and researchers handling filled-in questionnaires linked to individual students. Instead, questionnaires were coded and a front page with the students’ name on it added. Students were asked to remove the front page before handing the filled-in questionnaire to the teacher. Finally, information about consent included that participation was voluntary, what to do if a parent or a student did not want the student to participate, and contact details of the researchers for those who had further questions.

Regarding the interview/observation study teachers participating with their classes in the STSP were contacted and asked to participate. All
teachers asked were positive about participation. After that, the visit that included data collection was planned in collaboration with teachers. A week before the visit, we contacted the teachers and asked them to inform the class about our visit and to ask the selected students if they wanted to participate in the study. Teachers also handed out information sheets with consent forms for all students to bring home to their parents. Again, teachers, students and parents were informed about the research project and use of data, confidentiality and consent. Information about the research project included that the focus is on what happens during the lesson, how students work with the tasks they are given and how students experienced the lesson. It also included the connection between the motivation research project and the STSP, and that the long-term aim is to understand more about how science can be made more relevant for Swedish students. Information about confidentiality included that no names of students, teachers or schools will be mentioned in analysis, reports or presentations of the research. Finally, information about consent included that participation is voluntary, and that both parents and students could say no to participation. If the parents agreed to participation in the study, they should sign a consent-form and send it back to school. At the time of the classroom visit we (the researchers) introduced the study and ourselves, and again asked the selected students if they wanted to participate or not. Most said yes but a few said no, those who said no did not participate. Again, we used codes rather than names to identify recordings to avoid exposure of identities.
5. Results

Results from the four studies will be summarised briefly in sections 5.1-5.4. Section 5.5 contains a synthesis of the results from studies I-IV based on the two questions: (1) What classroom factors are important for students’ motivation and positive experiences and (2) How do students with different contextual motivation work with, and how do they experience working with an authentic approach to science. Finally, section 5.6 lists the most important results from studies I-IV and questions (1) and (2).

5.1 Study I – Predicting emotions
The study was conducted in a range of mathematics classroom situations. Student motivation was represented by variables extracted from motivation theories and the question asked was what personal and situational factors (among those included in the study) are most important for students’ positive activating emotions in the classroom.

The personal factors shown to be most important to predict positive activating emotions in the study were: intrinsic/identified motivation, mastery goals, and perceived learning. The situational factors shown to be most important to predict positive activating emotions in the study were: teacher enthusiasm, teacher support, autonomy support, peer attitude task novelty, and clarity of goals. The situational factors relate to feeling competence (clarity of goals and task novelty, as well as the personal factor perceived learning), autonomy (autonomy support) and relatedness (peer attitude and teacher enthusiasm), and can be explained with self-determination theory. Further, the important situational factors, I believe, are to a high degree, possible for the teacher to control in the classroom.

One variable, intrinsic/identified motivation or perceived learning, is able to predict up to 36% of the total variation in students’ positive emotions. When the 10 most important factors for predicting positive activating emotions are used in a model, the model describes 61% of the variation in students’ positive activating emotions, and the model can predict positive activating emotions to 59%.

5.2 Study II – Changes in motivation for science
Study II investigates how authentic science experiences can arrest the decline in secondary students’ motivation for science that is well-described in the archived literature, and how authentic experiences relates to students’ goals, values, beliefs and attitudes for science. The paper demonstrates that students’ intrinsic motivation for school science, their beliefs concerning knowledge as unrelated facts or a complex structure of interrelated concepts, and their plans for future participation in science remained unchanged at the
same time as significant downward changes were found in the students’
mastery- and performance goals, the utility value they see in school science,
their self-concept in and view of science. Effect sizes for the downward
changes were small or moderate. This means that the experiences of the
project the Medicine Hunt had potential to arrest the decline in students’
intrinsic motivation for science, but failed to arrest the decline in students’
goals, values and attitudes towards science. One possible explanation for this
is that students experience the Medicine Hunt as something positive but
separated from school science, and that this meeting between authentic
science and school science can result in a more insecure self-concept and less
confident self-reports about value of and goals with school science. That
authentic science can be experienced as something positive but separated
from ordinary school science suggests that the form the implementation of
the authentic project takes is central. Therefore, based on the findings, we
encourage stakeholders and teachers implementing authentic projects to
think beyond the notion of ‘authentic is positive’. One possible way to align
the authentic science experience to school science could be to explicitly
communicate to the students about how the authentic science project
connects with and differs from school science.

5.3 Study III – Students’ experiences
When students were interviewed about their experiences of participating in
the Medicine Hunt, most were positive. Twenty-one of 24 were positive
about the project the Medicine Hunt, and 22 of 24 were positive about the
lesson in which they morphologically analysed bacterial colonies. Students
were also positive in their over-all evaluation of the Medicine Hunt
(Lindberg, Hellgren, Lindqvist Forsberg, Almqvist & Nordqvist, 2014). To
learn more about if and how the positive experiences were related to science,
Study III analyses the reasons for students’ positive experiences.

Students’ positive experiences were primarily connected to authentic
science, to a high extent to science in general, and much less so to non-
science aspects. The experiences connected to authentic science could be
described through four categories. One, hands-on activities were defined as
opportunities to work actively and practically, for example to look at bacteria
in microscopes or to dig for soil samples. In their review of students’ interest,
motivation and attitudes Potvin and Hasni (2014) conclude that activities
that are only hands-on, without including inquiry or reflection, are not
sufficient to favour students’ interest, motivation and attitudes. The students
in the Medicine Hunt, however, particularly appreciated the hands-on parts
of the science. Two, inquiry-based activities were defined as students
referring to open-ended problems, taking own responsibility, or exploring
something unknown. Three, to get an extended view of authentic science is
defined as including activities that offer students possibilities to gain a better understanding of science beyond the school science they have already met in class. This includes, for example, making scientific posters and seeing if the work leads to an important finding. Four, continuity is defined as reasons that refer a sequence of lessons connected to each other and with focus on the same problem.

Students’ positive experiences were also connected to science in ways that are general for all science in school. Students appreciated both the variation added by the authentic research project and the possibilities to learn and/or to understand science better by participating in the project. A few of the students’ answers were connected to non-science aspects. Yet, these non-science aspects were positive comments, and connected to being selected to do something special and to participate in competition. Thus, students’ positive experiences were highly related to science and to the Medicine Hunt.

5.4 Study IV – Classroom opportunities and engagement

Focusing on the same Medicine Hunt lesson in three classrooms, Study IV looks at what opportunities students are given, in terms competence, autonomy and relatedness. The study also investigates how students with different contextual motivation for school science thrive in the three classrooms.

Results show that teachers give different opportunities for competence, autonomy or relatedness in their classrooms. In the first classroom, there are high opportunities for competence and relatedness and intermediate opportunities for autonomy. In the second classroom, there are intermediate opportunities for competence and low opportunities for autonomy and relatedness. In the third classroom, there are high opportunities for autonomy and relatedness, and mixed opportunities for competence, mainly due to weak support. Students take initiatives to science and procedure in all classrooms, and the dynamics of group work and lesson outcomes are good in the first and second classroom, but weaker in the third. There were no clear patterns regarding how students’ contextual motivation for science effect or are related to their classroom actions. However, it appears that high intrinsic motivation and good group work are a favourable combination for good lesson outcomes, and it can be seen that this is especially important in the third classroom with high autonomy and weak support.

5.5 Synthesis of results from studies I-IV

Results from Studies I and III are combined using competence, autonomy and relatedness as a framework to organise the factors, see Table 1.
Table 1. Factors important for students’ positive activating emotions (Study I) and experiences of authentic science (Study III) in the classroom. Factors are organised based on how they primarily support feelings of competence, autonomy or relatedness.

<table>
<thead>
<tr>
<th>Basic need</th>
<th>Study I</th>
<th>Study III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competence</td>
<td>perceived learning clarity of goals</td>
<td>opportunities to learn science</td>
</tr>
<tr>
<td></td>
<td>task novelty</td>
<td>extended view of authentic science</td>
</tr>
<tr>
<td>Autonomy</td>
<td>autonomy support</td>
<td>hands-on learning approaches</td>
</tr>
<tr>
<td>Relatedness</td>
<td>peer attitude</td>
<td>get continuity, get variation</td>
</tr>
<tr>
<td></td>
<td>teacher support</td>
<td>inquiry based learning approaches</td>
</tr>
<tr>
<td></td>
<td>teacher enthusiasm</td>
<td></td>
</tr>
</tbody>
</table>

This is done in order to discuss question (1), what classroom factors that are important for students’ motivation and positive experiences. Aspects of feeling competent and having opportunities to learn new things were important for the students in both Study I and Study III.

The relationship between task novelty (I)/variation (III) and positive emotions and experiences particularly supports the idea that authentic tasks can contribute to motivation in the science classroom. Aspects of autonomy (see Table 1) were also shown to be important in both studies; autonomy support was one of the most important factors in study I, and inquiry-based approaches in Study III. Finally, although aspects of relatedness were found to important in Study I, they were not mentioned by students in Study III.

Further, to discuss question (2), how do students with different contextual motivation work with, and how do they experience working with, an authentic approach to science, results from Studies II, III and IV were combined. Results from questionnaires (contextual motivation; intrinsic/extrinsic), interviews (how the student perceived the lesson and why), and from observations (initiatives and outcome) for the 12 students participating in Study IV are presented in Table 2.

For example, Emma has high intrinsic and low extrinsic motivation, she was positive towards the lesson and enjoyed it because she could work freely and talk to her friends, a reason that in Study III was classified as appreciating inquiry-based aspects of the Medicine Hunt. Emma took initiatives towards both science and procedure in her group work and had a good outcome, i.e., finished the task. Felix, on the other hand, had intermediate intrinsic and low extrinsic motivation, he was positive towards the lesson, but did not give any reasons for this. Felix took initiatives towards science but not towards procedure, and did not complete the task.

The table shows no clear pattern that supports a relationship between contextual motivation for science and outcomes.
Table 2. Overview of how students with different initial motivation for science experience and work with the authentic approach to science. Motivation is represented by intrinsic (IM) and extrinsic (EM) motivation that can be high (+), intermediate (o) or low (-). Experience is represented by overall outcome (positive, mixed or negative towards the lesson), followed by examples of reasons for students’ experiences. Actions in the classroom are represented by Initiatives that can be high (+), intermediate (o), or low (-), and Outcomes that can be good (+), mixed (o) or poor (-). Detailed descriptions of the scales can be found in Studies III and IV.

<table>
<thead>
<tr>
<th>Student</th>
<th>Motivation (IM/EM)</th>
<th>Experience (overall outcome + example quote)</th>
<th>Action (I/O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emma</td>
<td>+ / -</td>
<td>Positive: inquiry Work freely and talk to friends</td>
<td>+ / +</td>
</tr>
<tr>
<td>Eric</td>
<td>+ / o</td>
<td>Positive: hands on, understand science Whatever I do is fun, to work and use my skills</td>
<td>+ / +</td>
</tr>
<tr>
<td>Frida</td>
<td>+ / -</td>
<td>Positive: inquiry You can discuss with the person you work with, talk things through, check and see what you find</td>
<td>+ / +</td>
</tr>
<tr>
<td>Dora</td>
<td>o / -</td>
<td>Positive: no reasons I like science, it is fun when we do things like this</td>
<td>+ / +</td>
</tr>
<tr>
<td>Dave</td>
<td>- / +</td>
<td>Positive: hands on We could check out all the small fungi in the microscope</td>
<td>+ / +</td>
</tr>
<tr>
<td>Esteban</td>
<td>- / o</td>
<td>Negative: no reasons I never liked science, it is difficult, I have problems understanding</td>
<td>+ / +</td>
</tr>
<tr>
<td>Freya</td>
<td>+ / o</td>
<td>Positive: inquiry, continuity To see what happened to the soil samples, everything looked kind of different, one got curious what is was</td>
<td>+ / -</td>
</tr>
<tr>
<td>Desire</td>
<td>- / -</td>
<td>Positive: hands-on, variation [It was] different to what we usually do in science class, we don’t usually stand and dig on bacteria, we don’t usually look at bacteria, it is fun with something new</td>
<td>o / +</td>
</tr>
<tr>
<td>Edwin</td>
<td>o / +</td>
<td>Positive: understand science One gets to learn new things</td>
<td>o / o</td>
</tr>
<tr>
<td>Dean</td>
<td>+ / o</td>
<td>Positive: hands-on, inquiry, continuity To do this, check the samples, see what different shapes they could have</td>
<td>- / +</td>
</tr>
<tr>
<td>Felix</td>
<td>o / -</td>
<td>–</td>
<td>o / -</td>
</tr>
<tr>
<td>Frank</td>
<td>+ / +</td>
<td>Positive: continuity, something special Check what we had collected; when you were filming</td>
<td>o / -</td>
</tr>
</tbody>
</table>
Which class students are in seems to be more important for actions and outcomes. There is, however, a potential connection suggesting that students with lower levels of initiatives and poor outcomes enjoyed the lesson more.

5.6 Summary of results
The results of the various studies contributing to the thesis can be summarized as follows with origin of the result, in terms of study (I–IV) or question (1–2), shown within brackets:

The notion of having learnt something, and presence of intrinsic motivation, are the most important factors for students’ positive activating emotions in the classroom: (I).

Important situational factors for students’ positive activating emotions in the classroom are teachers’ support and enthusiasm, autonomy, clear goals, the peers’ attitudes and that the task is novel: (I).

Students’ positive experiences of the Medicine Hunt were shown to have the potential to arrest the well-documented decline in students’ intrinsic motivation for science, but failed to arrest the decline in students’ goals, values and attitudes towards science: (II).

Students were very positive to the Medicine Hunt, and they referred most of their positive experiences to authentic science, to a high extent to science in general, and little to non-science aspects. No differences based on students’ contextual motivation for science and small differences between classes were detected in students’ experiences: (III).

When implementing the Medicine Hunt, teachers gave different opportunities for motivation, through competence, autonomy or relatedness, in their classrooms. These differences appear to be more important for students’ initiatives, group work and outcomes in the classrooms than students initial motivation for science: (IV).

When introducing an authentic task, opportunities for motivation in the classroom have relevance for students’ engagement and outcomes: (IV).

Intrinsic motivation appears central for students’ positive emotions, but not for their engagement or experiences: (I + III + IV).

Of the situational factors, opportunities to feel competent via support and clear goals, autonomy – for example through student-centred inquiry based activities – and, to some extent, relatedness to teacher and peers, appear central for students’ engagement, positive emotions and experiences: (1; I + III).
When introducing an authentic task, there are no differences in engagement and experiences between students with different intrinsic or extrinsic motivation for science: (2; II + III + IV).
6. Discussion

In the discussion I show how this thesis contributes to our understanding of the importance of authentic tasks for student motivation in the science classroom. Further, I discuss the role of students’ motivation for science, as well as methods to study students’ motivation for science. I argue that authentic tasks can contribute significantly to school science, that situational factors in the classroom are of greater importance for students’ outcomes and experiences than students’ contextual motivation for science, and that more research starting in a situated perspective is needed to understand student motivation for science in greater detail, and that similar research is equally necessary in other school situations.

The discussion is divided in four sections. In Section 6.1, I discuss the main results from studies I, II, III and IV based on the two questions (1) and (2) posed in Section 2. In Section 6.2, I discuss results from the studies in relation to the purpose of the thesis: to interrogate how an authentic approach can influence students’ motivation for school science. Section 6.3 is an overall discussion about design and methodology used in the thesis, its strengths and limitations. Section 6.4 includes conclusions, recommendations for future research and teaching implications drawn from the results. The discussion focuses on the conclusions that can be drawn from a synthesis of the results of the individual studies. For detailed discussion of the specific results, see Studies I, II, III and IV.

6.1 Authentic science and motivation in the classroom — what can we learn?

The two questions (1) and (2) are discussed in sections 6.1.1 and 6.1.2 respectively. Question (1) What classroom factors are important for students’ positive emotions and experiences connects results from Study I to those of Study III and I discuss the similarities and differences, and draw conclusions based on a synthesis of the results of these studies. Question (2) How do students with different contextual motivation work with, and how do they experience working with an authentic approach to science, connects results from Studies II, III and IV by following, discussing and explaining results for the 12 students who were included in all three studies and were in focus in Study IV.

6.1.1 What classroom factors are important for students’ positive emotions and experiences?

Classroom factors important for students’ positive emotions and experiences were in focus in two of the studies; Studies I and III. The two studies have participants from different age groups (upper vs lower secondary school),
they focus on different school subjects (mathematics vs science), use different methodologies (quantitative with pre-determined answers vs quantitative with open questions and students own words), and have different variables as outcomes (positive activating emotions vs positive experiences). However, they both reveal something about what is important for students in the classroom. Study I took a starting point in a multi-method perspective including SDT as well as expectancy value theory and theories of goals, beliefs and emotions. The study showed that SDT was best suited to explain students’ positive activating emotions in the classroom. This is not surprising since SDT, of the theories included, is the theory that takes most emotional aspects into account. In Study III, an open question about what students appreciate was asked, answers were categorised, and again, many of the resultant categories were connected to the basic psychological needs competence, autonomy and relatedness. Basic needs theory (Ryan & Deci, 2000b) explains many aspects of students’ positive experiences in a range of situations in Swedish mathematics classrooms (Part A) as well as in the Medicine Hunt lessons including authentic science (Part B). Therefore competence, autonomy and relatedness were used as a framework for discussing Studies I and III.

In Study I, perceived learning and clear goals to guide the learning, and in Study III opportunities to learn science in general and authentic aspects of science in particular were examples of important factors closely associated with students’ feelings of competence.

Also associated to feelings of competence, but not as clearly, are the group of factors: task novelty (I), continuity (III) and variation (III). In earlier studies of students’ motivation, science topic has been shown central for students’ motivation (e.g. Bathgate, Schunn & Correnti, 2014; Nieswande & Shanahan, 2008). For example, a student may enjoy biology more when working with plant physiology than with human physiology, or physics more when working with mechanics than with astronomy. Task novelty is one aspect of topic that students in Study I find important for positive emotions; the Medicine Hunt is a novel and clearly contextualised topic/task introduced in the science classroom. As well as novelty, The Medicine Hunt includes aspects of value, which was also included as a factor in Study I. This factor, however, was not found to be one of the most important factors for positive activating emotions in the analysis. In Study III students relate to variation as well as the novel aspects they meet in the authentic science. Taken together, the relevance of novelty, continuity, variation and value support the proposition that authentic tasks have the potential to contribute to positive emotions and motivation in the science classroom through feelings of competence supported by development of new knowledge and skills.
Aspects of autonomy were also central in both studies. Teachers’ support for autonomy was one of the most important factors in Study I, and aspects from Study III were included in the category with inquiry-based learning approaches. Examples from students’ answers reflecting appreciation of autonomy include “it is more fun to work freely”, “take more responsibility in what we do”, and “we can decide more ourselves”.

Aspects possible to connect to relatedness were to some extent important in Study I, but not mentioned by students in Study III. All three types of aspects; competence, autonomy and relatedness, can be connected to teachers’ ways of interacting with students through questions and feedback. This is something that Kiemer, Groschner and Pehmer (2015) recently found to give positive changes in student motivation in a study of a teacher professional development programme. The teachers’ way of giving feedback, asking questions and replying to students’ answers to questions can, for example, give room for feeling competence with supportive suggestions for development, autonomy with being open rather than controlling, and relatedness by creating a classroom climate where it is allowed to share all types of questions and thoughts.

In sum, students’ conception of learning new things and autonomy through for example student-centred and inquiry-based activities, as well as novelty and contextual value are the three overall factors that are shown to be important for students’ positive activating emotions and positive experiences. In Study I we argue that the situational variables “provide specific guidance for teacher behaviours that are important for stimulating students’ positive emotions” (p. 686) and that the variables “describe teachers who have fully clarified the lesson goals, provide novel tasks, show enthusiasm for the subject and for teaching the particular class, provide sufficient explanations in a nice way, and keep track of students’ learning while supporting their autonomy” (p. 686). This was confirmed by study III, in spite of the difference in school subject, school year and methodology. Hence, in relation to classroom factors, this thesis has found that the contribution of authentic projects, or individual authentic tasks, is novelty, context and a more student-centred and inquiry-based way of working. This can enrich secondary science teaching and result in positive emotions and experiences. Further, when introducing new things and possibly new ways of working, it is central that the teacher supports students so they feel trust in their competences, supports the students’ autonomy, and works for a classroom climate that supports relatedness.

6.1.2 How do students with different contextual motivation work with, and how do they experience working with an authentic approach to science?

No patterns between students’ contextual motivation (i.e. their levels of intrinsic and/or extrinsic motivation in relation to school science as
measured in Study II) prior to the Medicine Hunt and their actions (Study IV) or experiences during the project (Study III) could be detected, see Table 2. The statistical analysis comparing students with high and low intrinsic motivation for science in Study III supports this finding. In Table 2, we can see that Emma and Frida both have high intrinsic and low extrinsic contextual motivation for science. In the classroom they take initiatives towards both science and procedure, and they have good outcomes of the task. Their experiences are positive and they both refer it to the inquiry-based way of working. Students with low intrinsic and intermediate (Esteban) or high (Dave) extrinsic motivation also take initiatives towards both science and procedure and have good outcomes. In a similar way, students with both high intrinsic motivation (Dean and Frank) and those with low motivation (Desire and Felix) are represented among students with poor outcomes. Therefore, both students with high and low intrinsic and/or extrinsic motivation for science engage and have positive experiences from the Medicine Hunt.

Regarding the overall quality of work, most students work in their groups throughout the lesson, take initiatives towards science and/or procedure, and most complete the task. However, the analysis suggests that the students in Anne’s and Beth’s classroom (students with names beginning with D or E) were more able to complete the task despite lack of initiatives, in comparison to Christine’s students (with names beginning with F).

Only one student of the twelve had negative experiences of the lesson, and this was Esteban who both took initiatives and completed the task. Esteban as well as two of the students with positive experiences (Eric and Dora) in the group who took initiatives and completed the task referred their experiences to stable contextual motivation for science; that is, that they either like science (Eric and Dora) or dislike science (Esteban) generally. Interestingly, reasons referring to stable contextual motivation for science were not mentioned in the group of students who took fewer initiatives and/or did not complete the task. Therefore, one might speculate that the Medicine Hunt to a higher degree gave similar experiences as ordinary lessons to the group who took initiatives and completed the task. This could mean that students with less stable contextual motivation for science are more open to noticing and appreciating contributions from novel authentic science activities than students with stable contextual motivation for science.

In sum, no patterns between students’ contextual motivation and their actions or experiences were found. Students with high and low intrinsic motivation for science were equally likely to engage in and enjoy participating in the project. It is, therefore, possible and advisable to design authentic science activities that can be part of the curriculum and reach a broad group of students.
6.2 How can an authentic approach influence students’ motivation for school science?
One of the objectives of the Medicine Hunt project, and the Help a Scientist programme, was to get secondary students more interested in science and research and to get them to study more science in the future. The proposition is that by adding authentic science to the teaching, through activities that fit into the school curriculum, allow interaction with scientists and support scientific work with authentic research problems with a relevant context, students would become more interested and learn more about what science can be outside school. Such positive experiences have potential to lead to better attitudes and higher motivation (Vallerand, 2000). However, this thesis’ findings in this area are not straightforward to interpret. The introduction of the authentic approach through the Medicine Hunt was accompanied by a downward shift in: students’ mastery and performance goals, in the utility value students saw in school science, in their self-concept in science, and their view of science. Intrinsic motivation, simplicity beliefs and plans for future participation in science remained unchanged. This result is discussed in detail in Study II.

Here I want to highlight the lack of connection between high classroom engagement and the positive experiences of the project reported by students on one hand, and the lack of positive effects on students’ goals, values, beliefs, and attitudes on the other hand. HMIEM (Vallerand, 2000) states that positive situational motivation has the potential to lead to better contextual motivation, and goals, values, beliefs, and attitudes are believed to be connected to motivation. However, there is no clear support for this connection from the results of this thesis. The reasons for this could be methodological, an effect of the project not being long enough, or that the Medicine Hunt lessons were parallel to ordinary science lessons, which students in all classes describe as more teacher-centred, for example, one student expressed that ordinary school science lessons are more about “read and answer questions in books”.

Despite the lack of positive changes in goals, values, beliefs, and attitudes, the Medicine Hunt was accompanied by positive trends in intrinsic motivation, not in exact numbers but in relation to the earlier described downward trend in intrinsic motivation over the school years (e.g. Gottfried, Fleming & Gottfried, 2001; Simpson & Oliver, 1990; Zusho, Pintrich & Coppola, 2003). Motivation, attitudes and similar factors are known to be difficult to change, and taken together, the results from this thesis indicate that students’ contextual motivation was possible to change without accompanying changes in the other related factors (goals, values, beliefs, and attitudes). Therefore, it is apparent that to tease apart these factors more
research is needed to understand the interaction between motivation and related factors.

I would also like to highlight some differences in outcomes between the classrooms. First, Anne’s students report they are more likely to make future choices including science, and Christine’s students have higher intrinsic/identified motivation for science after the STSP (however, this result from the pre- and post questionnaires should be handled with caution, changes are not statistically significant; data not shown). Second, Study III shows that Anne’s and Christine’s students report a higher degree of experiences related to authentic science compared to Beth’s students. It is not possible to say if the teaching style and opportunities given in the different classrooms are typical for implementation of the entire project, however, one can hypothesize this is the case. Then, Anne’s students, with good opportunities for motivation in the Medicine Hunt, gained a positive picture of what it is like to work with science and were more likely to consider studies or careers in science. Christine’s students, who were encouraged and gained a tight connection between their work and the scientists’ work, with not so much focus on goals or results, became more intrinsically motivated in relation to science. The reasons why Anne’s and Christine’s students report a higher degree of experiences related to authentic science compared to Beth’s students could be that Beth had a more procedural focus, and her students probably worked more towards procedural goals then the authentic aspects of the STSP, at least during this particular lesson.

In sum, the authentic approach in the Medicine Hunt supports engagement and positive experiences connected to science, even if small long-term benefits on students’ motivation for school science are detected. More focused studies are needed to elucidate possible relationships between students’ i) engagement and positive experiences, ii) students’ goals, values, beliefs, and attitudes, and iii) students contextual motivation for science.

6.3 Notes on design and methodology
This thesis contributes to the methodological aspects of motivation research by linking student motivation, as measured by questionnaires, to classroom actions and experiences in the science classroom. It has been a challenge, and it can be argued that I have been liberal in my interpretation of some theoretical concepts. The journey from planning a quantitative study with an experimental design and the following change in direction, to an approach where I put more focus on understanding what happens in the classroom when an authentic task is implemented, is described in detail in the book chapter Motivation in the science classroom (Hellgren, 2016), that is included in the volume Narratives of Doctoral Studies in Science Education,
Making the Transition from Educational Practitioner to Researcher. However, consequences of this change of direction has been that a basic assumption in the design, that students with different motivation focus act differently and experience different things, has been inherent in the design throughout the studies. At the same time, the context, the Medicine Hunt, has played a greater role the further I came in the work with the thesis. This reflects my own interest in the intervention as an example of authentic experiences in school, but also the development of my view of motivation with focus on the situation. Following this development, I let the results from one study influence the planning of the next, but since all data had been collected prior to the analysis, the freedom to make decisions about how data should be analysed was limited by the ways it was collected.

Another noteworthy limitation of this study is that Part A focuses on students in mathematics classrooms whereas Part B focuses on students in science classrooms. I make the assumption that students in mathematics and in science classrooms are similar in terms of which factors are important for their positive emotions. This assumption is made based on parallel studies in science and mathematics, where we decided to publish the data from the mathematics classrooms only, which resulted in Study I. However, when analysing data (not shown) the patterns for the two student groups were very similar. On the basis of this, I made the decision to base further studies on the results from Study I despite differences in student groups in terms of age and school subject. This decision was later supported by the similarities between results from Study I (mathematics) and Study III (science) when compared in question (1).

Further, there are some aspects related to the fact that Part B is a case study looking at one particular intervention that was not designed or evaluated by me. Rather, the studies are made from an outsiders’ perspective without being completely familiar with the thoughts behind each step or being able to design or develop them. This limits the design features that otherwise could have been built into the project before the studies were made, and those that could be made after, based on the outcomes of the studies. One such example is that more time than the eight lessons during six months included in the Medicine Hunt may be needed to see potential effects on student motivation and other motivation related factors when evaluated with questionnaires, if there are such effects. Also, looking at potential results related to motivation, it is not possible to say whether the observed changes are consequences of the Medicine Hunt or not since many other things took place during the same time period. A control group could have created a baseline for the motivation changes during the period, but it was difficult to find matching classes to the ones studied to make a reliable control group study.
The design of Part B also assumes there are differences between students based on their intrinsic/extrinsic motivation and mastery/performance goals as a result of Part A. These differences could not be detected which raises the question what effect this design has on the outcomes. My conclusion is that rather than creating groups to see differences between students it ensures that different types of students are represented in each classroom, and thus provides a realistic view of a classroom. However, different choices including fewer and more homogenous groups would have been a better basis for finding potential statistical differences between groups. The small and diverse groups studied in this thesis were tailored for an exploratory approach rather than for finding statistical differences. Therefore not finding any significant differences between groups should be handled with caution.

6.4 Conclusions, recommendations for research and implications
The first conclusion of the thesis concerns the value of authentic tasks. Authentic tasks can contribute to students’ engagement in the classroom, and to students’ positive experiences, by providing motivating situations. Authentic tasks provide a good way to introduce more inquiry, real-world context and connections to science as real research. These findings are significant because authentic, informal and out-of school learning-situations are common, but there is limited knowledge about their impact on short and long term motivation for, and learning of science in school. The findings are also relevant to the new Swedish National curriculum in science, since authentic science has potential to support students’ development towards a competence to examine information, communicate, take a view, carry out systematic studies and to use scientific concepts, models and theories to describe and explain relationships. This conclusion constitutes a contribution since it merges and specifies important roles authentic tasks can have in secondary school. It is also, to my knowledge, the first study of the implementation and contribution of a nationwide authentic project in a Swedish context.

The second conclusion of the thesis is theoretical/methodological and concerns the relationship between students’ motivation, engagement and experiences. The evidence for the importance of situational factors and the lack of evidence for the importance of personal motivation factors leads to the conclusion that more research on motivation from a situational perspective is needed. Recently, some researchers (e.g. Nolen, Horn & Ward, 2015; Potvin & Hasni, 2014; Turner 2001; Turner & Nolen, 2015) have addressed the limitations of the narrow focus in motivation research and argued for more research taking a starting point in other perspectives. For example, Potvin & Hasni (2014) argue that: “the use of questionnaires is so
common that it is not impossible that researchers have somehow lost sight of its limitations” (p. 111). Based on my results, I strongly support this view. My studies did not take a situative perspective, but rather explored how questionnaires can be complemented with interviews and observations in a mixed-methods design. This combined approach to motivation contributes to highlighting the complexity of motivation as a process in the classroom.

Based on the results and conclusions from the thesis, some suggestions for designing authentic tasks, implementing authentic tasks and for teaching can be made. First, when designing authentic tasks for school, this thesis shows that it is a good investment to direct the tasks to all students and not exclusively to students with high motivation for science. Continuity is, according to Study III, an important aspect and goes together with the importance of providing long-term opportunities in addition to isolated visits or excursions to for example science centres or museums. Therefore the teacher is a key resource in this work. Houseal, Abd-El-Khalick and Destefano (2014) suggested establishing long-term relationships between scientists and teachers, and in addition I would like to suggest allowing teacher education and teaching resources to become more powerful actors in the implementation of collaborations with scientists and of developing school science towards a more authentic approach. From the organiser’s point of view, this highlights the importance of support to the teachers and flexibility in the implementation process. This means that it is good to aim for development of within-curriculum programmes since the structure makes them possible to implement in classrooms and thereby reach all students.

Second, when implementing authentic tasks the balance between novelty and autonomy on one hand, and support and clear goals on the other hand appear to be a critical point for success, see Study IV. This agrees with earlier research, for example, Jang, Reeve and Deci (2010). This leads to the suggestion that teachers should plan the implementation according to the resources given so that each student still gets sufficient support in developing goals, attitudes and self-concept in science along with intrinsic types of motivation for science. This is particularly important around less self-regulated students (see Study IV). It is also valuable to consider what goals can be achieved through each sub-task. For example, to work with high autonomy and to practice scientific procedure are two important outcomes that can be achieved through the same task, and students in study III express that they appreciate variation. It is also advisable to take opportunities to engage in longer projects since it is possible that projects that are too short and not well enough established in the teaching have a risk that they turn into “happenings” without long-term effects on affective values associated with science.
Third, many of the features the students appreciated with the authentic experience, for example continuity, variation, hands-on and inquiry based methods, and work with real-world problems are possible to implement in ordinary everyday teaching, without participating in a specific programme (see Study III). Through teacher education, professional development courses for in-service teachers and school resources for work more with inquiry-based and hands on science this could be achieved in all secondary classrooms. Such approach could contribute to avoiding students experiences of science as difficult, decontextualized and taught with a transmissive pedagogy (Lyons, 2006). Further, it would support teachers to help students work towards the goals, (The Swedish National Agency for Education, 2011) and bring together the humanistic and traditional views of science in school.

Students see great value in many of the aspects inherent to authentic science, both in terms of science content, and in the scientific way of working. A more explorative and authentic experience of science is for everyone and not exclusively for those with high motivation for and plans for future participation in science. Authentic experiences can arrest decline in intrinsic motivation for science in the secondary school years and support plans for more involvement in science activities. Our future scientists, engineers, journalists and politicians with responsibilities for important science-related issues in society may well be among those who traditional school science does not appeal and would not without an extra impetuous, such as that provided by an STSP or other authentic science activity, seek alternative approaches to science outside school. For our future, we need to support ways that assure authentic aspects of science reach every school student.
References


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I also want to thank my family and friends for love and support and for coping with me doing this once again. It was the last time, I promise!

Umeå, April 2016,
Jenny
Appendices

Appendix A: Part A, Questionnaire 1
Appendix B: Part A, Questionnaire 2
Appendix C: Part B, Questionnaire
Appendix D: Part B, Interview guide