Teaching in social science uses many visual representations, such as models, flowcharts and diagrams, in order to help students to grasp phenomena, structures and processes in society. However, it is a challenge to use a visual simplification of a complex reality without reducing its complexity, and we often do not know what understanding is facilitated or even hindered through the different visual representations we use. This thesis focuses upon the relationship between teaching and learning of dynamic phenomena and processes in social science and the use of visual representations in social science teaching. The study focuses on upper secondary teaching and uses pricing in economics as an example of a complex and dynamic process in social science. The thesis discusses and presents results concerning the relationship between how a content is visually illustrated and how students understand the content visualised, as well as the relationship between visual representations used in teaching and the teaching-learning practices established in the classroom. The thesis argues for the importance of reflecting on what visual representations to use in social science teaching and presents practical implications for teaching.
Making Possible by Making Visible
Learning through Visual Representations in Social Science
Ann-Sofie Jägerskog

Abstract
This thesis focuses upon the relationship between teaching and learning of dynamic phenomena and processes in social science and the use of visual representations in social science teaching. Teaching in social science uses many visual representations, such as models, flowcharts and diagrams, in order to help students to grasp phenomena, structures and processes in society. However, it is a challenge to use a visual simplification of a complex reality without reducing its complexity, and we often do not know what understanding is facilitated or even hindered through the use of different visual representations. We thus need to identify the relationship between how the content is visually illustrated and composed (compositional structure) and how students understand the content visualised. We also need to improve our understanding of the relationship between visual representations used in teaching and the teaching-learning practices established in the classroom. This thesis aims to contribute to these areas, with a focus on visual representations of pricing in economics, as an example of a complex and dynamic process in social science.

Paper I uses phenomenography and variation theory to investigate students’ conceptions of causal relationships in pricing. Causality was identified as a central dimension of variation in understanding pricing. Different conceptions of causality in pricing were identified in upper secondary students’ written answers and critical aspects of causal relationships in pricing were identified. Paper II compares the outcome of using two different visual representations of pricing. This paper draws attention to the ways in which these representations helped students to discern the critical aspects identified in Paper I. A causal loop diagram was considerably more effective than supply/demand graphs in helping students to discern the critical aspects of causal relationships in pricing. A conclusion drawn is that the compositional structure of a visual representation used in teaching plays a vital role for how students understood the content visualised and which aspects of the phenomenon are more easily discerned, and which are not. Paper III uses a practice theory perspective to deepen the understanding of the results from Paper II. Results from Paper III suggest that the causal loop diagram, to a greater extent than the graph, contributed to the establishing of an epistemic practice, a practice where knowledge was developed and transformed. This was for instance seen in the causal loop diagram affording discussions concerning the causal relationships and encouraging further questions and reflections. A conclusion drawn is that a visual representation as an action-mediating tool plays a central role in forming the teaching-learning practices established in the classroom.

The results from the three papers are also discussed in relation to two challenges: (i) how simplified visualisations of complex processes and structures may facilitate students developing a qualified understanding of such processes and structures and (ii) how disciplinary developed visual representations, when used in social science teaching, may be used with a different goal than when used in the discipline, where they were developed. The contributions of this thesis are both empirical, theoretical and practical and several practical implications for teaching and learning in social science were identified.

Keywords: social science teaching, visual representation, pricing, causal relationships, teaching and learning, phenomenography, variation theory, practice theory, teaching-learning practice, epistemic practices, upper secondary school, design research, graphs, economics, social studies.

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MAKING POSSIBLE BY MAKING VISIBLE
Ann-Sofie Jägerskog
Making Possible by Making Visible
Learning through Visual Representations in Social Science

Ann-Sofie Jägerskog
To Isak, Moa, Olivia & Micke
List of studies


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1. Introduction and setting the scene

Throughout history, we have often tried to grasp and simplify complexities in the world around us and we have a long tradition of trying to do so through the use of visual representations (Comenius, 2006/1682). Much teaching tries to grasp complex and dynamic phenomena and to help students develop a qualified understanding of dynamic processes and structures. Visual representations are often used in this attempt and social science education is no exception. This thesis focuses upon the relationship between teaching and learning of dynamic phenomena and processes and the use of visual representations in social science education.

Understanding society means understanding many rather complex and dynamic structures and processes. Helping students to develop an understanding of those different processes and structures is one of the tasks for school in general and teaching in social science in particular. Understanding structures and processes in society is important for several reasons. For instance, such an understanding has the potential to facilitate more well-grounded decisions in everyday life, which help an individual to play a constructive role in society and enable students’ agency as citizens (Davies, 2006; Sandahl, 2015). Accordingly, an important aspect of learning in social science includes developing an understanding of complex, dynamic and sometimes rather abstract phenomena, structures and processes in society.

However, this creates challenges for teaching. One challenge is that complex processes and phenomena are difficult to capture in teaching, especially given the limited time frame a lesson or a lesson sequence offers. Also, a visual illustration is a simplification of a complex reality, which could be considered its strength, but also its weakness. It is a challenge to use a visual simplification of a complex reality without reducing its complexity. Also, there is a risk that focus is placed on trying to understand the representation itself, but not necessarily the underlying and deeper complexities of the phenomenon visualised, and that focus is placed on entities rather than the relations involved (Goldwater & Schalk, 2016).

Teaching in social science uses many visual representations (such as models, flowcharts and diagrams) in everyday teaching and course material. However, we often do not know what understanding of the content the visual representation we use actually facilitates or even hinders. Likewise, we often do not know how, or the extent to which, these visual representations help students develop a more qualified understanding of the complexities presented.
In social science, where we aim to develop students’ understanding of complexities in society and where we often use visual representations to help students to develop and qualify such understanding, we need to identify what role visual representations may play in teaching and learning. We also need to identify how the compositional structure of those representations may relate to students’ understanding of the content visualised, as well as the teaching-learning practices established in the classroom. This thesis aims to contribute to these areas, with a focus on visual representations of pricing in economics, as an example of a complex and dynamic process in social science.

**Pricing in economics as the case**

Social science examines interrelations between phenomena. Understanding that relations are often bidirectional rather than unidirectional, and that different entities mutually affect each other, is a key to understanding many processes in social science, not the least in economics. Pricing is a good example, where demand not only affects price, but where price also affects demand. Likewise, supply does not only affect price, but price also affects supply. Similar interrelations could be identified in areas such as environmental costs and setting of wage rates. This thesis uses pricing as the case for investigating how visual representations can facilitate students developing a more qualified understanding of dynamic interrelations. Pricing and economics are central parts in social science teaching. However, we know from earlier research that students struggle with understanding pricing and often develop a rather simplified understanding of this rather dynamic phenomenon (see, for instance, Cohn, Cohn, Balch & Bradley, 2004; Davies, 2012, 2019; Davies & Mangan, 2013; Estrada, 2013). Pricing is also an area where visual representations traditionally have been used in order to explain the relations and processes involved. Pricing is thus, for several reasons, a good case to use in order to investigate the relation between learning of complexities and the visual representation used in teaching.

Two different visual representations of pricing will be used in this thesis, a traditional supply/demand graph (Figure 5, p. 43) and a causal loop diagram (Figure 6, p. 43 developed from Wheat, 2007a). Both representations are developed within an economics discipline. The supply and demand graph was developed to explain ‘neo-classical’ economics, whereas the loop diagram was developed in the field of system dynamics. Both representations illustrate the relationships between supply, demand and price. However, they differ in terms of compositional structure and in terms of what they primarily aim to illustrate. The compositional structure of a visual representation could be understood as how the content is visually illustrated and composed: what aspects of the phenomenon visualised are highlighted, thus placed in the foreground versus background. In the supply/demand graph, causality is implied in the curves and how they relate to each other. In the causal loop diagram, causality
is more directly visually illustrated through arrows connecting supply, price and demand. As for the goal of the two visual representations, the supply demand graph has the goal of illustrating the function of a whole economy on an aggregate level, the mathematics behind pricing and price elasticity, thus explain where and how price emerges. The causal loop diagram, developed in a system dynamics disciplinary context, has the goal of visualising the dynamic processes through which prices change. The role of the compositional structure as well as the role of the goal of a visual representation will be investigated and discussed in this thesis.

Social science – a school subject with several disciplinary roots

Social science is in Sweden a school subject studied by all students in both compulsory and upper secondary school. The school subject has a national curriculum, which means that all students, regardless of what school they attend, are given the same course. Although upper secondary school is not compulsory, the vast majority of all 16-19 year olds go to upper secondary school. All schools are in Sweden state funded and offered to all children without charge.

Social science in a Swedish context is a multidisciplinary subject, with roots in several different disciplines, such as political science, sociology and economics (Kristiansson, 2015; Olsson, 2016; Sandahl, 2018). Social science, in contrast to many other school subjects, thus does not have a direct equivalence among the academic disciplines (Bronäs & Selander, 2002: Larsson, 2011; Lindmark, 2013; Sandahl, 2018). This lack of an academic ‘mother discipline’, and the school subject’s relationship to several academic disciplines, has led to a discussion concerning whether social science is a fragmented school subject (Sandahl, 2018). Some argue that due to its fragmentary character and its lack of one clear disciplinary residence, the subject is in a crisis (Barr, Barth & Shermis, 1977; Bronäs & Selander, 2002). Others argue that this description of the subject is not reflected in teachers’ view on and way of describing their own subject (Morrissett & Haas, 1982; Olsson, 2016). A lack of a single disciplinary residence for social science thus does not seem to be considered a problem for social science teachers. Rather than considering it fragmented, teachers seem to view social science as a clear and holistic school subject (Olsson, 2016). Similarly, Barton and Avery (2016) emphasise the diversity of the subject as a strength rather than a weakness, arguing for the importance of several different perspectives to be applied in order to understand such a complex field as social science is expected to cover. If social science aims at investigating and understanding political, social and economic phenomena in society, a multidisciplinary approach should rather be consid-
ered a necessity. A third possible view on this matter is that the multidisciplinary residence for social science as a school subject is a strength, but that it also entails challenges that need to be dealt with. One such challenge concerns the use of visual representations in teaching, which will be discussed in this thesis and further elaborated below (in the section “Challenges addresses in this thesis” below).

When discussing the relationship between social science as a school subject and the academic disciplines to which it relates, it is also relevant to highlight the fact that the school subject serves a different goal than the disciplines (Sandahl, 2018). Nordgren (2017, p. 668) expresses this difference in terms of the school subject having a broader purpose than the academic disciplines: “It is broader since its intended goal is not only the production or acquisition of knowledge but also the serving of societal, cultural and individual expectations. While research has no limits of interest beyond its own paradigms (and founding), a school subject needs principles of relevance, and while a discipline advances through specialization, the subject needs syntheses and pedagogical rationales.” This difference in goals between social science as a school subject and the academic disciplines is a key to understanding social science in relation to the academic disciplines to which it relates. This difference in goals between a discipline and a school subject also becomes relevant when we deal with visual representations. A visual representation that stems from an academic discipline may be used in the discipline with one goal, but due to the broader purpose of the school subject, be used with another goal in the instructional setting. This aspect will be further discussed in this thesis and will be further elaborated below.

Challenges addressed in the thesis

This thesis was prompted by two different, but related, challenges concerning visual representations in teaching and learning in social science: (i) how visual representations in social science, although being simplifications of complex processes and structures, may facilitate students developing a qualified understanding of such processes and structures and (ii) how disciplinary developed visual representations, when used in social science teaching, may be used with a different goal than when used in the discipline, where it was developed.

Challenge 1: Visual representations as simplified illustrations of complexities

One of the great possibilities with the use of visual representations in teaching and learning in social science is also one of the major challenges: a visual representation has the potential to present a complex reality in a simplified way. As the visual representation often presents a simplification of complex
processes, it risks being misunderstood and result in a too simplified understanding of different concepts and phenomena (Cohn, Cohn, Balch & Bradley, 2001; Colander, 1991; Davies & Mangan, 2013; Wheat, 2007a). For instance, when used in textbooks and teaching situations, visual representations are often presented as two-dimensional models (Wheat, 2007a). Such two-dimensional representations may create problems for students, as they are static representations of dynamic processes and relations (Cohn et al., 2001; Davies & Mangan, 2013). However, teaching often uses simplified representations, with the aim of facilitating students’ understanding of complexities. This involves several challenges. One such challenge is that we in teaching often use visual representations without really knowing to what extent, or in what way, they facilitate, or even hinder, a complex and qualified understanding of the content visualised. This thesis deals with this challenge by investigating the relation between learning of pricing, in terms of students’ developed conceptions of pricing and teaching-learning practices established in the classroom, and the visual representation used in teaching.

Challenge 2: Different goals of a visual representation - when used in the discipline and when used in social science teaching

Visual representations used in teaching and learning are often drawn from the discipline(s) to which the school subject relates. This implies that although many of the visual representations used in teaching are created by the teachers themselves, many visual representations used for instructional purposes in the classroom are disciplinary developed. This entails both possibilities and challenges. One possibility is that disciplinary models and representations may convey and visualise the core of a subject content necessary for students to grasp. Another possibility is that understanding visual representations that are central to that discipline could be considered part of what it means to master a discipline (Airey & Linder, 2009; Davies & Mangan, 2013). Learning in a certain knowledge domain includes an increasingly developed ability to handle, or coming to appropriately interpret and use, different established tools, such as semiotic resources, in this knowledge domain (Airey & Linder, 2009, 2017; Selander, 2008). A challenge, however, is that the purpose of a visual representation when it is used within a discipline is not necessarily the same as the purpose when it is used in teaching the school subject. This assumption stems from a practice theory perspective, where a foundational assumption is that each practice (for instance a disciplinary practice and a social science teaching practice) is specific in what it aims to accomplish. This in turn affects how tools, such as visual representations, are used and what they afford in the practice (Wertsch, 1998) (see Chapter 4 for further elaboration of practice theory perspective). The challenge mentioned above becomes critical in social science, as this school subject stems from several different disciplines. There may thus be a difference, that the teacher needs to be aware of and deal with, between the purpose of the disciplinary developed visual representation when
used in the discipline and when applied in social science teaching. Accordingly, a visual representation taken from one practice, such as political science, sociology or economy, and used in another, such as social science education, may cause challenges in the teaching and learning situation. One example that illustrates this challenge is visual representations of pricing. Traditionally, in an economics discipline, a supply/demand graph is used to visualise the functioning of a whole economy, the mathematics behind pricing, as well as price elasticity. However, when applied in a teaching situation, it is often used to illustrate causality in pricing, thus the relationships between supply, price and demand, but not necessarily on an aggregate level. Rather than being used to illustrate relationships between prices in different markets, as is the case within the discipline, the supply/demand graph is often used in social science teaching in order to understand the operation of price in particular circumstances as it relates to other aspects of society. This thesis investigates the possible challenge of potential differences between the goal of a disciplinary developed visual representation when used in the discipline and when used for instructional purposes in social science upper secondary teaching.

What is a visual representation?

Visual representations are in this thesis defined in line with Ingerman’s (Ingerman, Linder & Marshall, 2009, p. 3) definition of the concept: “a model that represents a phenomenon, situation or construct (or parts of them) in a particular way, namely bringing certain aspects of the phenomenon, situation or construct to the fore while allowing other aspects to recede into the background”. This definition highlights four important aspects of how visual representations are considered in this thesis. First, visual representations are understood as models, thus visually illustrated concepts or phenomena. Examples of such models are flowcharts, diagrams and graphs. Photos are thus not included in this definition. Second, a visual representation is considered to represent something, such as a phenomenon, situation or construct. This implies that visual representations should not be considered an image of how things ‘are’, but as an attempt to grasp aspects of a phenomenon, situation or construct. This leads on to the third aspect of how visual representations are considered in this thesis: a visual representation illustrates something in a particular way. This implies that a phenomenon can be illustrated in multiple ways. Fourth, a visual representation brings some aspects to the fore, while others recede in the background. Depending on how a phenomenon is illustrated, different aspects will be highlighted. This implies that different aspects of a phenomenon may be possible to discern through different visual representations.
Disposition and focus for the thesis

It is a challenge to help students develop a deeper and more qualified understanding of complex processes and relations in social science. The ambition with this thesis is to contribute with insights to such a challenge in relation to the use of visual representations. The focus will be on how visual representations of pricing, as a case of interrelations in social science, can facilitate a qualified understanding of the processes involved. The overall aim of this thesis is to contribute to the understanding of how visual representations can facilitate learning of dynamic interrelations in social science, with a specific focus on pricing in economics, in upper secondary school. More specifically this thesis investigates (i) what role the compositional structure of a visual representation of pricing plays in developing students’ conceptions of causality in pricing and for the teaching-learning practices established in the classroom, and (ii) what role the relation between the goal of a visual representation when it is used within an economics discipline and the goal when it is used in social science teaching in upper secondary school, plays for what learning of causality is made available.

The thesis is outlined as follows: In the following chapter (Chapter 2), I first give a background to how this thesis builds on the earlier published licentiate thesis (Jägerskog, 2015), followed by an overview of earlier research in the field, with a focus on social science education, teaching and learning through visual representations and students’ conceptions of causation in pricing. In Chapter 3, the general aim and research questions are presented in relation to the different papers included in this thesis. The three papers will also briefly be related to the three above mentioned research fields. Chapter 4 presents the theoretical perspectives used, followed in Chapter 5 by a presentation and justification of the methodological and ethical choices made. The three papers included are summarised in Chapter 6 and discussed in light of the challenges presented above in Chapter 7. In Chapter 8, the results are further discussed, and conclusions are drawn in relation to social science education.
2. Background and earlier research

The licentiate thesis as a springboard

This thesis builds on an earlier published licentiate thesis (Jägerskog, 2015), investigating to what extent the use of a visual representation of the structure of memory in psychology teaching can facilitate upper secondary students’ learning of the content. One of the studies (Jägerskog, Jönsson, Selander & Jonsson, 2019) focused on the combination of two different learning strategies, both found robust in earlier studies: multimedia learning (learning through the use of visual representations in combination with verbal communication) and retrieval practice (learning by actively retrieving what has been previously studied). Both multimedia learning (Mayer, 2011), based on the notion that individuals learn better from words and pictures presented together than from words alone (Paivio, 1986), and retrieval practice (Roediger & Karpicke, 2006), based on the idea that retrieving knowledge from the memory is an active process that has a beneficial impact on learning, have been found robust learning strategies when investigated in isolation from each other (see, for instance, Mayer, 2009; Roediger & Karpicke, 2006, for reviews). However, in earlier research those two learning strategies have been compared to learning strategies known to be less effective (learning through words only, or re-studying only), and they have not been investigated in combination, something which would be of relevance for teachers and students in their efforts to identify ways to further facilitate learning.

Results showed that multimedia learning, or the use of a visual representation, was a much more powerful learning strategy than retrieval practice. The second study (Jägerskog & Jönsson, 2015) investigated the beneficial effects of the use of visual representations in more detail in terms of individual preference for verbal or visual learning. Results showed that the positive effects of learning with the help of a visual representation holds independently of preferred way of learning (visual or verbal). A total of 215 upper secondary students from twelve classes in three different schools participated in the study. A lecture on how the memory works was being held in all classes. In half of the classes a visual representation, outlining the flow from sensory memory, to short-term memory and to long-term memory, was drawn simultaneously on the whiteboard. Students were then asked to work with the material presented (through restudying or writing down everything they could remember from the presentation). Students were also asked to fill in a questionnaire concerning preference for visual versus verbal learning. At the end
of the lesson students were asked to complete a post-test with six questions concerning the content focused upon in the lesson. The same test was conducted one and ten weeks later. Data were analysed statistically.

The licentiate thesis summarised above (Jägerskog, 2015) serves as a springboard for the thesis you now read (referred to as ‘this thesis’). The focus in this thesis is thus a direct response to insights gained through, or questions raised from, the research conducted in the licentiate thesis. This holds for the subject content in focus, as well as for some other aspects: the role of the visual representation, research focus, methods and theoretical perspectives used. These different aspects will be further presented below and are summarised in Table 1.

First, the subject and content focused upon in this thesis has been chosen in light of the subject and content in focus for the licentiate thesis. The latter focused on psychology and the structure of the memory, whereas the former focuses on social science/economics and the causal relationships in pricing. Both contents exemplify complex and dynamic processes in the social sciences, often difficult for students to grasp. They are also both examples of processes often visually illustrated by the teacher, or in course material, in order to facilitate for students to develop an understanding of the processes involved. However, there is a clear difference between the two subjects and contents in terms of visual representations. Psychology as a subject does not generally have a shared visual language. There is, for instance, not one particular and generally accepted way of illustrating the structure of the memory. Also, the discipline as such does not offer many visual representations that are commonly used in teaching in order for students to better understand different complex processes in psychology. Illustrations used in psychology teaching are more often created by individual teachers, authors or publishers and the visual representations of a certain content therefore often differ between different course materials and classrooms. In contrast, economics, being a part of social science as a subject, has a much more developed and shared visual language. Many of the visual representations used in economics teaching (such as visual representations illustrating pricing and a circular flow of income) are generally used. Accordingly, similar illustrations are often used in different course materials and different classrooms. It is a deliberate choice to focus on visual representations of pricing in economics, as part of social science teaching, in order to investigate learning through visual representations in a subject where there is a clear common, and even ‘institutionalised’ visual language, as opposed to psychology and the structure of the memory.

Second, there is a difference in how the role of the visual representation is considered. In the licentiate thesis, the use of a visual representation in teaching was considered a learning strategy and was related to another learning strategy – retrieval practice. What was focused upon was thus the visual representation as a general tool (although illustrating a specific subject content). In this thesis, the visual representation is considered a model that represents a subject specific content in a particular way by highlighting certain aspects
(Ingerman, et al., 2009) and as an action-mediating tool in a practice (Wertsch, 1998). As a consequence, this thesis focuses on what learning is facilitated through the use of two different visual representations of the same content (pricing), rather than whether or not a visual representation as a general tool facilitates learning. With this shift in focus, this thesis contributes with a broadened understanding of how a visual representation can facilitate learning of dynamic interrelations in social science.

Third, and as a natural consequence of what was just described concerning the role of visual representations in the two publications, the research focus is different in this thesis in comparison to the licentiate thesis. The licentiate thesis focused questions concerning if and to what extent a visual representation facilitates learning, and results showed that using a visual representation is a much more beneficial learning strategy than retrieval practice (Jägerskog et al., 2019). This result is interesting, but it also raises further questions. Results demonstrating that the use of a visual representation is a very robust learning strategy, even more robust than retrieval practice, raises question of how or in what way. This thesis therefore focuses on investigating students’ conceptions of causality in pricing in relation to two different visual representations of this content, and by investigating what teaching-learning practices are established in relation to the different visual representations used. Focusing on how or in what way a certain visual representation facilitates (or does not facilitate) learning of a certain content can provide a deeper understanding of learning of complex processes in social science through visual representations.

Fourth, and logically following the different foci mentioned above (if and to what extent versus how and in what way), this thesis uses different methods for analysing data compared to the licentiate thesis. In order to answer questions concerning if or to what extent a visual representation of the structure of the memory facilitates learning (as was the case in the licentiate thesis), quantitative analysis methods were used. In this thesis, I focus on students’ conceptions of causality in pricing, and teaching-learning practices established in the classroom in relation to the different visual representations used. The methods for analysis are therefore different in the two publications. This thesis uses mainly qualitative methods (phenomenography and variation theory as well as analysis of communicative actions) in order to be able to address the ‘how’- and ‘in what way’-questions raised above.

Finally, in the licentiate thesis, the theoretical perspective used was cognitive psychology (in terms of cognitive theory of multimedia learning, CTML). Much earlier research on learning through visual representations, including my licentiate thesis, uses a cognitive approach to learning through visual representations. In this thesis I use phenomenography and variation theory as well as a practice theory perspective to widen the discussion on how and in what way the use of visual representations may facilitate learning. By including those theoretical perspectives, this thesis can deepen the understanding of, and
widen the discussion on the use of visual representations in learning about dynamic interrelations in social science.

In sum, this thesis builds on an earlier written licentiate thesis (Jägerskog, 2015), and I thereby, through the work conducted in the realm of this doctoral thesis, will extend and deepen the insights gained in the licentiate thesis.

Table 1. The relation between the licentiate thesis (Jägerskog, 2015) and this doctoral thesis in terms of subject and content in focus, as well as aspects in focus.

<table>
<thead>
<tr>
<th>Learning of dynamic interrelations through visual representations</th>
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<tbody>
<tr>
<td><strong>Licentiate thesis</strong></td>
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<tr>
<td><strong>Subject and content in focus</strong></td>
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<tr>
<td>Subject in focus and content visualised</td>
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<td>The subject’s visual language</td>
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<td>Aspects in focus</td>
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<td>Role of the visual representation</td>
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<td>Research focus</td>
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<td>Methods for analysing data</td>
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<tr>
<td>Theory of the visual representation</td>
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<td>Methods for analysing data</td>
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<tr>
<td>Theoretical perspective</td>
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<td>Cognitive perspective</td>
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Scope and demarcation

This thesis could be placed in the overlap between three different research fields: teaching and learning in social science, learning through visual representations and students’ conceptions of price (Figure 1). The results presented in this thesis have the potential to contribute to all three research fields.

In the following sections, I will give an overview of the three research fields presented above, with a focus on the overlapping fields in Figure 1. This means that my intention is not to give an overview of the three fields in general, but in relation to each other. First, research on teaching and learning in social science, with a focus on learning through visual representations will be presented. Second, research on learning through visual representations, with a focus on price, will be discussed. Third, previous research on students’ conceptions of price will be presented. Finally, research on the relationship between visual representations and teaching and learning in the classroom, using a phenomenographic and variation theory perspective will be briefly presented, as phenomenography and variation theory are used in this thesis to analyse data and to deepen the understanding of teaching and learning through visual representations.

The identification of earlier research related to this thesis has been conducted in several different ways and in several steps. Parts of the literature review was conducted in relation to the licentiate thesis. As the research fields relevant for this thesis are partly different from the fields in focus for the li-
centiate thesis, a new literature search has also been conducted. In the literature search in different databases, key words such as visual representation/visual illustration/visualization/visual tool, social science(s), social studies, civics, teaching, learning and classroom were applied in different combinations. In searching for relevant literature on pricing and economics teaching, graph, price and economics have been used as key words in addition to the ones mentioned above. Several relevant studies from other subject domains, such as the natural sciences and mathematics, have been identified and used as a reference point in the literature review below, but I have limited my main scope to social science. Also, as I am investigating the use of visual representations in terms of models and diagrams, studies focusing on film, art, photo, maps and classroom display have been excluded from the literature review.

I will now present an overview of the three research fields presented above, with a focus on the overlapping fields in Figure 1.

Teaching and learning in social science

As mentioned earlier, teaching and learning in social science often includes developing an understanding of complex, dynamic and sometimes rather abstract concepts, phenomena and relations. The complexity in the social sciences are highlighted by several scholars. Goldwater and Schalk (2016) suggest that learning involves developing an understanding of complex processes, relations and interactions between both individuals and structures. They distinguish between intrinsic features and extrinsic relations, arguing that students need to understand not only superficial features, but also the deep relational structures in the content being learnt. The difference between a novice and an expert in a subject, they argue, is the ability to see the latter (Goldwater & Schalk, 2016). Lundholm (2018) highlights that causality in terms of being intentional, uni- and multi directional in the social sciences (in contrast to the natural sciences) is central when it comes to learning and understanding core concepts (e.g. pricing) and Goldwater and Schalk (2016) argue that the relations are often not single, but that there are also relations between the relations. Another key aspect of grasping complexities in social science seems to be understanding causality. Sandahl (2015) suggests analysing causality as one of the key thinking tools necessary for students to develop in order to improve social science thinking. Likewise, Rottman and colleagues (Rottman, Gentner & Goldwater, 2012 p. 929) argue that “an understanding of causal systems is crucial to explaining and predicting complex phenomena (...) in social and economic spheres”.

As mentioned in the introduction, one example of such a ‘causal system’, being both complex and dynamic, is economy in the subject ‘social science’ in Swedish upper secondary education. In the Swedish national curriculum for social science, it is stated that students should develop an understanding of
how “economic conditions affect and are affected by individuals, groups and structures in the society” (The Swedish National Agency for Education, 2011). Pricing, being an example of interrelations, is a key concept in economics and is central in the teaching of upper secondary school economics. This thesis will use pricing as a case when investigating what role the compositional structure of a visual representation plays for qualifying students’ conceptions of the content visualised and for the teaching-learning practices established in the classroom.

I will now turn to the use of visual representations in social sciences teaching and learning.

**Visual representations in social sciences teaching and learning**

Much of the research on learning and visual representations has been conducted within the field of natural sciences and mathematics (see for instance Berg, Orraryd, Pettersson & Hultén, 2019; Cho, 2013; Haruskamp, Mayer & Suhe, 2007; Johnson & Mayer, 2009; Kartal, 2010; Ozcelik, Arslan-Ari & Cagiltay, 2010; Roth, 2003, 2014; Rundgren & Tibell, 2009; Seufert, Schutze & Brunken, 2009). Thus, empirical research, as well as theoretical discussions, concerning learning through visual representations has been given focus in the field of science teaching and learning (see, for instance, Booth & Ingerman, 2008; Danielsson, 2010; Fredlund, Airey & Linder, 2012, 2015a; Fredlund, Linder & Airey, 2015b; Ingerman et al., 2009), rather than the field of social science teaching, although there are examples of this kind of research also in the social sciences (see, for instance, Berson & Berson, 2009; Hall, Kent, McCulley, Davis & Wanzek, 2013; Hammett & Mather, 2011; Lim, 2001; Roberts & Brugar, 2017; Stenliden, 2014; Stenliden, Nissen & Bodén, 2017; Westelinck, Valcke, Craene & Kirschner, 2005).

Researchers highlight different aspects concerning the use of visual representations in the learning of social sciences. Three such aspects are (i) the occurrence of them in books and everyday teaching, (ii) their importance for developing social science thinking and (iii) their possible effects on learning.

First, the occurrence of visual representations in the social sciences is often compared to that of the natural sciences. Visual illustrations are a common and natural part of teaching and learning in the natural sciences, often used in order to explain difficult and abstract concepts and deepen the understanding of certain content. In the social sciences, visual representations and illustrations are not as frequently used, or are rather used as decorative or motivational ingredients. Pauwels (2000) argues that there is a current dominance of camera image in social science. Walking into a social science classroom does often not involve the many visual illustrations and representations used in a natural sciences classroom.

Second, some researches highlight visual representations as possible ways of developing abstract thinking in the social sciences. Sandahl (2015) explores possible ‘second order concepts’ in social science (developed by Lee, 2005,
in relation to historical understanding). These second order concepts are considered thinking tools needed to analyse, organise, discuss and critically review the subject content. One of the six second order concepts suggested by Sandahl (2015) is using abstractions, such as visual representations, to simplify and understand complex structures and phenomena. He also argues that moving between the abstract and the concrete is an essential part of learning in social science. Similarly, Hill and Stegner (2003) argue that although many students may struggle with visual representations, it is important to use visual representations in order for students to develop a more abstract way of thinking.

Third, some researchers question whether visual representations have the potential to facilitate learning in the social sciences as they do in the natural sciences. Westelinck and colleagues (2005) argue, based on a study with 190 university students studying educational sciences, that the multimedia effect, suggesting that people learn better when a text or lecture is combined with pictures than from words alone, is not generally applicable in the social sciences. In contrast to the natural sciences, they argue, visual representations in the social sciences are not built on a consensual iconic sign system previously acquired or mastered by the students. Further, they suggest that representations in the field of natural sciences are intuitive and depictive in nature, which often is not the case within the social sciences. In contrast, other researchers suggest that the use of visual representations can play an important role in social science teaching and learning. Hall and colleagues (2013) showed that graphic organisers and visual mnemonics can function as helpful tools for students with learning disabilities when they read social science text and learn social science content on their own. In a design-based research project with 15 teachers from primary and secondary schools, Stenliden and colleagues (2017) demonstrated the benefits of using a story telling tool, as an example of a visual analytics tool, in social science teaching. Similarly, through a case study with two teachers and two classes in an A-levels economics course, Lim (2001) demonstrated the benefits of using a ‘CAL package’ in economics, an interactive digital package with tutorials, visual representations, animations, etc. Lim’s (2001) study also highlighted the importance of providing task-orientation, critical reflection and narratives in relation to the visual representations used in teaching.

Although there are studies investigating learning through visual representations in the social sciences, not many studies focus on what role the visual representations play for qualifying students’ conceptions of the phenomena illustrated. In order to develop the understanding of how visual tools can facilitate learning in social science, research is needed addressing questions concerning what learning is facilitated through different frequently used visual representations in social science and how such representations can deepen students’ understanding of a certain concept/phenomenon. The aim of this work is doing just that, with a focus on pricing in economics.
Learning through visual representations

In the following sections, the relationship between learning and visual representations will be discussed in general and with a focus on economics teaching in particular.

The relationship between learning and visual representations

Scholars highlight different important functions that a visual representation can have in teaching and learning. First, some researchers highlight that visual representations have the potential to offer a way of capturing subject content that in itself cannot be directly perceived (Buckley, 2000; Davies & Mangan, 2013). In doing so they can represent a bridge between the theoretic and abstract to the more concrete (Booth & Ingerman, 2008; Ewenstein & Whyte, 2009; Van Dijk, Van Oers, Terwel & Van den Eeden, 2003). Second, researchers also emphasise that visual representations can be a tool for strategic thinking in the meaning that they can guide and structure thinking (Van Dijk et al., 2003), as well as illustrate a way of thinking (Colander, 1995). In doing so, the representations may help learners to understand the systems represented and offer an idea of how different variables may interact (Colander, 1995; Mayer, 1989). Third, and as mentioned earlier, visual representations are suggested to have the potential to represent a complex reality in a somewhat more simplified way (Sandahl, 2015; Van Dijk et al., 2003). In that sense a visual representation could be considered a “snapshot of a dynamic process” (Davies & Mangan, 2013, p. 192), a role which obviously could be seen as one of the major challenges when using visual representations in learning economics. Fourth, visual representations could be considered part of the subject specific disciplinary discourse, necessary for students to gradually become familiar with in order to become literate in that subject (Airey & Linder, 2009; Danielsson, 2011). In that sense, visual representations function as a necessary and integrated part of knowing a subject, as the subject content of any school subject cannot be separated from the texts (including visual representations) used in learning that content (Danielsson, 2010). Put differently, “the ways of knowing that constitute a discipline are inseparable from their discursive representations” (Airey & Linder, 2009, p. 28). Fifth, as expressed in the practice theory perspective, the visual representation as an artefact has the potential to form the teaching-learning practices and thereby facilitate students’ learning (Schatzki, 2001; Wertsch, 1998). This implies that the function of a visual representation can be understood as something active – the visual representation in use, rather than merely the visual representation as such. The five possible roles of a visual representation summarised above (bridging between the abstract and the concrete, structuring and illustrating student thinking, simplifying a complex reality, being an integral part of the subject specific discourse, as well as forming the teaching-learning practices) are not exclusive. Accordingly, visual representations, such as the two visual representations of pricing
investigated in this thesis, can potentially facilitate learning in all those five aspects.

Another aspect highlighted by researchers concerning the possible impact of visual representations on learning is that visual representations have the potential to create motivation, generate excitement and focus attention in general (Brody, 1982; Peeck, 1993), which is thought to facilitate learning. However, this aspect is not focused upon in this thesis.

Visual representations in economics teaching and learning

In this section, I focus on teaching and learning through visual representations in a context of teaching and learning economics. I first present research investigating learning through different visual representations of the same content (pricing), followed by research looking into the beneficial effects of using visual representations in economics teaching and learning and challenges with using them.

Learning through different visual representations of the same content

Much research looking into learning through visual representations investigate how students understand the visual representation (see, for instance, Davies & Mangan, 2013; Roberts & Brugar, 2017; Rundgren, 2012), general benefits of using visual representations (see, for instance, Berson & Berson, 2009, Hall et al., 2013; Hammett & Mather, 2011; Lim, 2001; Stenliden et al., 2017), or compare using a visual representation with not using it (see, for instance, Cohn et al., 2001; Kourilsky & Wittrock, 1987; Mayer, Bove, Bryman, Mars & Tapango, 1996). Not much research has been conducted comparing how different visual representations of the same subject content relate to students’ understanding of the content. However, in a series of experiments, Wheat (2007b) investigated the effect of using two different visual representations of pricing when introducing business cycle dynamics to undergraduates. Alongside the traditional supply/demand graph, he used a different way of illustrating pricing in order for students to grasp the dynamics and complexities embedded in the concept of price: the feedback method. The idea behind the feedback method is to use feedback loop diagrams rather than static graphs or equations, encouraging and enabling students to learn dynamics before they learn calculus, in order to develop an understanding for economic behaviour. In four experiments, Wheat (2007b) investigated the feedback method in terms of student preference and performance. The results showed that students preferred the casual loop diagram before the static graph (both when learning and explaining price) and that the performance, in terms of scoring on a multiple-choice test, was better when the causal loop diagram had been used rather than the static graph. A causal loop diagram resulted in better understanding of business cycle dynamics than learning with static supply/demand graphs. However, Wheat (2007b) did not further investigate the difference in students’ understanding of pricing when learning with the help of the
causal loop diagram or the static graph. He did not examine what aspects, necessary for students to discern in order to develop their understanding of pricing, were made possible through the use of the different representations. Wheat (2007a) suggested that future research should focus on how students form their understanding of processes in economics. This thesis will focus on students’ understanding of the content visualised in relation to the design/compositional structure of the visual representation and how the visual representations used relate to teaching-learning practices established in the classroom. It will use a phenomenography and variation theory perspective (Paper II) as well as a practice theory perspective (Paper III) in seeking to reveal ways in which visual representations can facilitate learning.

Are visual representations beneficial in economics teaching and learning?

It could be considered likely that visual representations could facilitate learning in the area of economics, as learning in economics involves understanding abstract and complex processes, relations and interactions that cannot be observed directly, and as visual illustrations are considered able to illustrate and simplify such structures and phenomena (Buckley, 2000; Cook, 2006; Sandahl, 2015). Visual representations of different kinds, such as graphs and circular flows, are frequently used in economics textbooks as well as in everyday teaching and lecturing in economics (Reimann, 2004, Cohn et al., 2004, Wheat, 2007a). This frequent use of visual representations suggests that visual representations are a useful way of facilitating learning of economic concepts (Wheat, 2007a).

However, research shows that the beneficial effects of using visual representations, such as graphs, in economics teaching and learning are not that straight forward and there are studies questioning those beneficial effects. In two experiments conducted by Cohn and colleagues (2001), 208 university students who were presented graphs in the lectures alongside a verbal presentation had the same or significantly lower scores on the learning test than students in the no-graphs lecture. Through interviews with 38 university students Davies and Mangan (2013) identified different conceptions of the role of graphs and concluded that the different conceptions also affected the students’ understanding of the subject. Strober and Cook (1992) reported about students who claim to understand ideas in economics when presented verbally, but that they became confused when the same ideas were presented in graphs. Likewise, they reported about students who talked correctly about the concepts (for instance ‘shortage’) but drew graphs inaccurately. To some degree students also seemed to distrust the relevance of graphs and diagrams to the ‘real world’ (Strober & Cook, 1992) and many students found it difficult to draw the graph and often drew graphs inaccurately, which had a negative effect on their understanding of the graph and of pricing as a phenomenon (Cohn & Cohn, 1994). In contrast to the results presented by Cohn and colleagues (2001), Kourilsky and Wittrock (1987) found that the combination of verbal presentation and graphs resulted in better student learning than verbal presentation.
only. However, results were better if the verbal presentation preceded the graph than if graphs were presented first. Further, in a study with 78 students it was concluded that students receiving instructor supplied graphs printed on the lecture notes excelled students with no supplied graphs, in terms of scores on the exam (Cohn & Cohn, 1994). Therefore, previous research has not settled (i) whether visual representations are beneficial for learning in economics or (ii) how visual representations in economics affect learning. Also, much of the research in this field has examined whether a graph or a model adds to a verbal explanation. A practice theory perspective approaches the problem in a different way and offers the prospect of extending the knowledge in this research field by using a different perspective.

Previous research has also examined whether visual representations in economics help some students more than others. Results from these studies suggest that there are no gender differences. However, students with a preference towards maths and logic, and students with graduate parents, seem to benefit more from graphs when learning about pricing (Hill & Stegner, 2003). In this thesis, student differences will not be focused upon.

**Challenges with visual representations in economics teaching and learning**

Several researchers have tried to identify and understand the possible problems and challenges with visual representations (such as graphs and circular flows) used in economics teaching and learning. On a more general level, one such challenge seems to be that dynamic and complex systems and processes are simplified and therefore also easily misunderstood when presented as a statically drawn visual representation (Cohn et al., 2001; Davies & Mangan, 2013; Wheat 2007a). A key challenge here is that a two-dimensional graphical representation cannot simultaneously visualise interaction of several variables within the same graphical space and this limits the complexity that can be visualised (Ruiz Estrada, 2012; Reingewertz, 2013). It seems to be of great importance that students understand that a visual representation in economics is oversimplifying the complexities it aims to illustrate (Strober & Cook, 1992). Another challenge on a more general level is the risk of the model discouraging a deeper thinking about the inner workings of the model and the phenomena behind it (Colander, 1995). In addition, students do not necessarily see in the representation what professionals see in it, which could suggest that a representation needs to be designed in a way that captures the students’ understanding (Van Dijk et al., 2003).

On a more specific level, focusing on supply/demand graphs, several studies show that there are many challenges connected to learning with this particular graph. Strober and Cook (1992) videotaped student conversations as students in small groups tried to graphically solve an economic problem about a shortage in local labour. A couple of different problems were identified. One problem (also highlighted by, for instance, Kourilsky, 1993 and Zetland, Russo & Yavapolkul, 2010), was labelling axes and understanding whether
price as an individual variable should be placed on the vertical or horizontal axis. Another problem was that some students did not treat the graphs as representing phenomena in the real world (Davies & Mangan, 2013). According to Strober & Cook (1992, p. 143), students seemed to be “confused about which aspects of the real world they could usefully include in the graphs they drew”. Many students seemed to find graphs difficult to understand and did not consider them helpful in the learning situation (Cohn et al., 2004). The notions of ‘equilibrium’ and ‘shortage’ were particularly problematic, as students did not see that the concept of equilibrium had implications for supply as well as for demand and that shortage should be understood as equivalent to limited quantity, i.e. rarity. The researchers concluded that one reason why students have problems with visual graphs in economics could be that they lack understanding of key concepts. One example of this could be the common conception among students that supply is the single cause of price (Ignell, Davies & Lundholm, 2017).

Despite the many problems and challenges related to visual representations in economics in general and with supply/demand graphs in particular, learning to use economic representations is by some considered central in order to really learn and understand the subject (Davies & Mangan, 2013). Identifying challenges and problems with visual representations used in economics teaching is important in this strive, however, it needs to be complemented with research identifying what learning is made possible through different visual representations, which this thesis aims at doing.

**Research on students’ conceptions of price**

Students’ conceptions of price have been investigated in several previous studies. Many of them have used phenomenographic method in identifying conceptions of price and the different studies have suggested different dimensions of variation in conceptions of price.

Dahlgren (1984) and Pang and Marton (2005) provided evidence of variation in conceptions of *how quantity demanded or supplied was related to price*. Results from Pang and Marton’s study showed that students had qualitatively different ways of understanding change in price: (i) as change in the features of the goods, (ii) as a change in supply, (iii) as a change in demand, or (iv) as a change in both supply and demand (with or without considering the relative magnitude of the change). Similar categorisations were reported in studies conducted by researchers in social psychology (e.g. Leiser & Halachmi, 2006; Thompson & Siegler, 2000), although they did not use phenomenography as the method for their analysis. Further, Pang and Marton (2003) provided evidence of variation in conceptions of *how a given change in price might affect quantity demanded or supplied*. They investigated how teaching about price elasticity (the slope of the demand curve/supply curve) and its effect on market price, could be carried out in a powerful way and identified
four different conceptions of the slope of the demand/supply curve: (i) no recognition of the possibility of variation in the slope of either supply or demand, (ii) recognition of variation in the slope of demand, but not supply, (iii) recognition of variation in the slope of supply, but not demand and (iv) recognition of variation in the slope of both demand and supply. When summarising research results concerning student conceptions of price from studies in different research traditions, Davies (2011) concluded that five qualitative distinctions in understanding price seemed to occur: price reflecting intrinsic worth, price reflecting supply, price reflecting demand, price reflecting the combination of supply and demand and finally price reflecting the relative magnitude of changes in supply and demand.

Davies (2011, 2019) and Durden (2018) identified yet another dimension of variation in conceptions of price – that of price as a decision of an individual producer or as an outcome of market forces. Three different conceptions were identified: (i) prices assumed to be decided upon by individual producers, (ii) prices determined by market forces and (iii) prices being dependent on competition and market norm.

In a study investigating qualitative differences in reasoning about what the price should be for different goods, Davies and Lundholm (2012) presented different categories of foundations for the reasoning, such as normality, necessity and equity, using up resources, or price signal to consumers.

Davies and Lundholm (2012) concluded that many studies investigating student understanding of pricing have three things in common in their results: (i) there seems to be a small number of qualitatively distinct ways of understanding price, (ii) the different ways can be defined in terms of how supply and demand are connected to price, and (iii) there seems to be an increase in sophistication of students’ way of reasoning. Further, Davies (2019) reviewed literature on economics in a conceptual change framework and identified characteristics of mainstream ‘everyday thinking’ about price and economics. Among other things, he suggested that everyday conceptions of price are dependent on context (what type of product it is related to) and that everyday reasoning about price is often characterised by considering price as unidirectional and set by individual sellers.

The studies mentioned above all focus on teaching and learning of price. However, none of them specifically focuses on variation in conceptions of causation in pricing, i.e. the interaction between demand, supply and price, as a distinct dimension in conceptions of price. Causation in pricing really matters in conceptions of economics phenomena, because everyday reasoning typically uses unidirectional conceptions of causation, although conceptions suggested by the discipline of economics emphasise bidirectional views of causation within economic systems (e.g. Leijonhufvud, 1969; Lundholm & Davies, 2013; Lundholm, 2018). In an overview of conceptual change research in economics, Lundholm and Davies (2013) concluded that one challenge in understanding price is due to everyday reasoning on causation in
terms of unidirectional relations. In economics however, causation is multidirectional and there are feedback loops. Understanding pricing in terms of causal relationships are in focus for the studies in this thesis. Also, previous studies on students’ conceptions of price do not specifically focus on what understanding of price is made possible in relation to different visual representations. This thesis aims at contributing with this.

Research on visual representations from a phenomenography and variation theory perspective

A small portion of research using phenomenography and variation theory (see Chapter 4 and 5 for a further elaboration on phenomenography and variation theory) has focused on visual representations. Some recent studies in the natural sciences, with a focus on physics, have examined visual representations from a phenomenographic and variation theory perspective. There are mainly three ways in which phenomenography and variation theory in these studies have been used to analyse learning in relation to visual representations. First, students’ understanding of the role of a visual representation was analysed using phenomenographic analysis (Booth & Ingerman, 2008). Booth and Ingerman investigated how students understood the role of a computer simulation, illustrating Bohr’s atom model, as an agent for reasoning about the phenomenon. Second, some studies have argued for visual representations facilitating aspects of a phenomenon to be experienced and discerned by the students (Booth & Ingerman, 2008; Fredlund et al., 2015a; Ingerman et al., 2009). Looking into visual representations used in higher education physics teaching, these studies suggested that a visual representation of a subject content highlights certain ‘critical aspects’ of this phenomenon, (a key concept in variation theory, see Chapter 4 for further elaboration), which in turn helps students to notice variation in those aspects. Fredlund and colleagues (2015a) suggest that identifying aspects of a phenomenon that need to be discerned and selecting representations that illustrate them, are two factors that can enhance learning through visual representations. Third, Fredlund and colleagues (2015b) suggest the possibility of identifying critical aspects of a phenomenon through visual representations, such as diagrams and images. They suggest that diagrams and images have been an under-explored way of identifying critical aspects of an object of learning and that a social semiotics perspective has the potential to identify critical aspects in a new way. The function of different semiotic resources used in teaching (in their case within physics education), Fredlund and colleagues suggest, is “to express and coordinate the critical aspects as efficiently as possible” (Fredlund et al., 2015b, p. 307).

In this thesis (Paper II), the second aspect mentioned above will be especially focused upon, as students’ conceptions of causality in pricing will be
analysed in light of the visual representations used in teaching and critical aspects discerned through those representations. Applying a phenomenography and variation theory perspective on learning through visual representations is relevant for teaching, as visual representations are often used, but not always reflected upon in terms of what learning is made possible through them.

Summary of earlier research and the contributions of this thesis

Earlier research on visual representations in teaching and learning has generated a profound knowledge base. However, there are still gaps that need to be further investigated. Based on previous research, I have identified four gaps where this thesis could contribute with further insights.

First, previous research on teaching and learning in economics has identified different aspects of students’ conceptions of price. What has not been further investigated in students’ understanding of price is the notion of causality, thus the interrelations between supply, price and demand. As causation is central in pricing, it would be relevant to identify how students understand causation in pricing and what aspects are necessary for students to discern in order to develop more complex and qualified conceptions of causality, thus what teaching and visual representations of pricing need to focus. Paper I in this thesis investigates causality as a central dimension in developing qualified conceptions of pricing, as well as aspects necessary to discern in relation to this.

Second, we know from earlier research that the use of visual representations may be very helpful in the learning process, but also that two-dimensional representations may create problems for students, as the representations are often simplifications of a complex reality. However, what we do not know much about is how different two-dimensional visual representations of the same subject content (i) may contribute to complex understanding of the content visualised and (ii) may relate to the teaching-learning practices in which the visual representations are used. These are aspects where we need to extend our knowledge if we want to understand how two-dimensional visual representations can help students to develop a complex understanding of the content visualised. In focusing on teaching and learning of causal relationships in pricing, in light of different visual representations used in teaching, this thesis can contribute with further insights to this issue. Therefore, Paper II focuses on what knowing/learning is facilitated by using each of two different visual representations of the same subject content (causal relationships in pricing). Paper II uses a phenomenography and variation theory perspective. Paper III investigates what teaching-learning practices are established, and
thereby also what learning is made possible, when different visual representations of pricing are used in teaching. This paper uses a practice theory perspective.

Third, much research on the use of visual representations in teaching and learning is limited to answering whether learning outcomes are greater with or without using a particular visual representation. Conclusions from earlier studies on using visual representations in teaching and learning are often (i) that visual representations in economics may not be helpful or may even be counterproductive, (ii) that students find certain representations difficult to grasp, and (iii) that visual representations involve difficulties, such as a possible simplified understanding of complex phenomena and processes. Those studies give us important information about general difficulties in learning through certain visual representations. However, knowing that a visual representation involves difficulties in the learning situation may not be enough and we therefore need to complement this research of whether, for instance, different graphs aid learning in economics with what knowing/learning is facilitated with different visual representations. In order to further understand how visual representations can facilitate learning of key concepts in economics, such as pricing, and thereby suggest implications for teaching, we probably have much to gain from also including aspects of what understanding is facilitated by different visual representations and how different visual representations may relate to teaching-learning practices established. By taking a phenomenography and variation theory as well as a practice theory perspective on the use of visual representations in teaching and learning, this thesis contributes with such knowledge, in order to further expand our understanding of how visual representations can facilitate learning of key concepts in economics. In Papers II and III respectively, those theoretical perspectives are used to shed new light on the role of visual representations in teaching and learning of economics as part of social science.

Fourth, studies investigating the use of visual representations in teaching and learning have mainly been conducted within the natural sciences and with less focus on social science. Consequently, we know rather less about what learning is facilitated by visual representations in social science. Several researchers have argued that learning should be viewed in relation to its subject-specific content, since learning may be domain-specific rather than domain-general (Caillot, 2007; Mayer, 2004; Shulman, 2004; Shulman & Quinlan, 1996). Similarly, Airey and Linder (2009) argue that each discipline has its own discourse, including for instance disciplinary specific representations, which implies that learning through visual representation needs to be investigated in relation to its subject specific domain, rather than to learning in general. As some researchers suggest that visual representations are not as applicable in the social sciences as in the natural sciences (Westelinck et al., 2005) and as we do not know much about how some frequently used visual representations in social science teaching are understood by the students and what knowing/learning they facilitate, studies investigating learning with the use of
visual representations in social science are needed in order to shed more light on this issue. If we lack knowledge about learning with and through visual illustrations in social science, we risk missing out on illustrations that could facilitate learning and we risk using illustrations that do not facilitate learning the way we want them or believe them to do. In the present work, visual representations from economics (as a case of interrelations in social science) will be in focus. Cohn and colleagues (2001) suggested that graphs may not be helpful, or even counterproductive, in certain circumstances. Instructors should therefore, they claim, re-evaluate the use of visual representations in economics teaching. I suggest that this re-evaluation needs to be grounded in research, where students’ understanding of some frequently used visual representations is investigated, something which is focused upon in this thesis. When focusing on student understanding of a concept, clues could be found concerning what aspects need to be clarified and made discernible/possible to experience for the students in order for them to develop a deeper understanding of the concept. This thesis contributes with this within the field of social science education and economics.

In addition, many studies in economics investigating the use of graphs and other visual representations focus on university students (see, for instance, Davies & Mangan, 2013; Hill & Stegner, 2003; Ruiz Estrada, 2012; Strober & Cook, 1992; Zetland et al., 2010) or younger children (see, for instance, Berti & Grivet, 1990; Kourilsky, 2001; Leiser & Halachmi, 2006; Marks & Kotula, 2009; Thompson & Siegler, 2000). Fewer studies have been conducted with students in upper secondary education (but see, for instance, Ignell et al., 2017; Pang, 2016; Pang & Marton, 2003; Pang & Marton, 2005); an age group considered to have a low understanding of economic concepts and in need of a developed financial literacy (Davies, 2006; Pang, 2016). The studies in this thesis therefor focus on this particular age group.

This thesis will make empirical, theoretical and practical contributions. An empirical contribution could be insights into areas not thoroughly investigated in earlier research in terms of learning through visual illustrations in social science with a focus on economics. Insights into students’ conceptions of pricing, through the use of different visual representations, as well as the practices established in classrooms where they are used, would be important empirical contributions. A theoretical contribution could be a discussion concerning how phenomenography and variation theory can contribute to a research field focusing on teaching and learning through visual representations. The results from the studies will also be discussed in terms of implications for teaching, which will be a practical contribution to, for instance, teachers in upper secondary school, as well as to people developing and designing course material. Research focusing visual representations in social science, with a focus on pricing, may provide insights into how the subject content could be visually presented in a way that enables students to develop a complex understanding of the processes, structures and causal relations involved.
Earlier research on graphs and causal loop diagram as a starting point

This thesis is not hypothesis driven. However, the two visual representations used (a supply/demand graph and a causal loop diagram) have previously been investigated by Wheat (2007b). As has been presented earlier in the background section (more specifically in “Learning through different visual representations of the same content”), results from Wheat’s studies showed that students preferred the causal loop diagram to the static graph (both when learning about and explaining price) and that the performance, in terms of scoring on a multiple-choice test, was better when the causal loop diagram had been used rather than the static graph. These results provided a starting point for this thesis. However, the research questions for this thesis, as presented below, do not aim to test Wheat’s conclusions. Rather than testing a hypothesis concerning the two visual representations, this thesis aims to deepen and widen the insights gained from Wheat’s research by investigating the two visual representations in relation to students’ conceptions of causality in pricing and teaching-learning practices established in the classroom.
3. General aim, research questions and studies included

The overall aim of this thesis is to contribute to the understanding of how visual representations can facilitate learning of dynamic interrelations in social science, with a specific focus on pricing in economics, in upper secondary school. The questions in focus are:

1. What role does the compositional structure of a visual representation of pricing (in terms of a supply/demand graph and a causal loop diagram) play in developing students’ conceptions of causality in pricing and for the teaching-learning practices established in the classroom?

2. What role does the relation between (i) the goal of a visual representation when it is used within an economics discipline and (ii) the goal when it is used in social science teaching in upper secondary school, play for what learning of causality is made available?

How the research questions relate to the three papers included in the thesis

Three papers are included in this thesis (see Figure 2). The first research question will mainly be discussed in the light of the empirical findings presented in Paper II and III. Paper II focuses on how students’ conceptions of causality in pricing develop in relation to two different visual representations of pricing used in teaching and Paper III investigates how two different visual representations of pricing relate to what teaching-learning practices are established in the classroom. Paper I investigates students’ conceptions of causality in pricing and forms the basis for Paper II. This first research question will also be discussed in more depth in Chapter 7 (Summary and discussion of results).

The second question, focusing on the relation between the goal of a visual representation when it is used within an economics discipline and the goal when it is used in social science teaching in upper secondary school, is primarily discussed in Chapter 7 (Summary and discussion of results). However, the foundation for this discussion is laid in Papers II and III.
The three papers included in this thesis are clearly related to each other (see Figure 2). In Paper I, causation is identified as a central dimension in understanding price and this paper functions as an outset for Paper II. In Paper II, students’ conceptions of causation in pricing are related to two different visual representations of pricing used in teaching, identifying students’ conceptions of causation in pricing before and after a lesson sequence introducing pricing. Paper III deepens the insights gained in Paper II by analysing how the two different visual representations of pricing are related to the teaching-learning practices established during a lesson sequence held between the pre- and post-tests analysed in Paper II. The three papers are further related to the licentiate thesis, as presented in the background section.

Figure 2. Illustration of how the papers relate to each other.

How the three papers relate to the research fields

The three papers included in this thesis could also be understood in relation to the different research fields presented above (teaching and learning in social science, learning through visual representations and students’ conceptions of price). Paper I contributes to the research field investigating students’ conceptions of price, as it deepens the understanding of causality as an important dimension in understanding pricing – an aspect relevant for teaching aiming to develop an understanding of pricing. Paper II and III are contributions to the overlapping field of teaching and learning in social science, learning through visual representations and students’ conceptions of pricing, as they present results concerning teaching and learning of price in the social science classroom through the use of visual representations (see Figure 3).
Figure 3. Illustration of research fields relevant for this thesis and how the three papers relate to the different research fields.
4. Theoretical perspectives

Stiles (2009, p. 9) defines scientific theories as “descriptions of aspects of the world…. (that) knit observations together, suggesting how observations of one thing may indicate that other things have taken place or will take place”. In the papers presented, I use two theoretical perspectives to knit together and interpret the observations made in four social science classrooms, where two different visual representations of pricing were used in teaching. The two theoretical perspectives are (i) phenomenography in combination with variation theory and (ii) practice theory perspective. Phenomenography in combination with variation theory is used in Papers I and II in order to identify students’ conceptions of causality in pricing and to examine the impact of different visual representations on the development of conceptions. A practice theory perspective is used in Paper III in order deepen the insights gained from Paper II. Paper III focuses on identifying what teaching-learning practices are established in the classroom when different visual representations of pricing are being used in teaching, thus what happens during the lessons in terms of students’ and teachers’ communicative actions and the goals driving them. The two theoretical perspectives therefore complement each other and are presented below in terms of central ideas and how the perspectives are used in this thesis.

Phenomenography and variation theory

Phenomenography is a research approach aiming at identifying and describing different ways of experiencing a phenomenon (Larsson, 1986; Marton, 1981, 2015; Marton & Booth, 1997). Variation theory is a theory of teaching and learning, developed in relation to phenomenography, and focuses on what someone needs to discern in order to develop a more complex way of experiencing it (Marton, 2015; Marton & Booth, 1997; Runesson, 2017). A basic assumption in phenomenography is that learners can understand or experience a phenomenon in qualitatively different ways, known as ‘conceptions’. Conceptions are not to be considered stable cognitive conceptions and an individual is thus not considered to hold one certain conception about a phenomenon. Instead, an individual could express different conceptions of a phenomenon in different contexts. This implies that changing the context could lead to an individual experiencing the same phenomenon in a different way (Marton &
A basic assumption in variation theory is that learning is always directed at something (an object of learning) and that learning is understood as developing more complex ways of understanding, ‘seeing’, or experiencing this object of learning (Marton & Booth, 1997; Marton, 2015). This means that learning is seen as a qualitative change in the way one ‘sees’, or experiences, something (Mun Ling & Marton, 2011).

Critical aspects of a phenomenon
In phenomenography, conceptions of a phenomenon are often organised in a hierarchy, an ‘outcome space’, where a more complex conception is contrasted with less complex conceptions. The conceptions are distinguished by aspects of the phenomenon that need to be discerned by the student in order to develop a more qualified way of understanding it (Collier-Reed & Ingerman, 2013; Marton, 2015). It is in those aspects that “the critical differences amongst different ways of experiencing or seeing lies” (Pang & Ki, 2016, p. 323). As those aspects are critical for learners to discern in order to see or experience the object of learning the intended way, they are called ‘critical aspects’ (Mun Ling & Marton, 2011; Pang & Ki, 2016), a notion which is central in variation theory. These aspects are considered especially critical for learners who have not yet discerned them (Pang & Ki, 2016). Identifying critical aspects of an object of learning is thus crucial in order to facilitate learning (Lo, 2012; Marton & Booth, 1997; Marton, Tsui, Chik, Ko & Lo, 2004). However, identifying critical aspects is not a straightforward task (Wood, 2013). Teachers may sometimes take for granted what they believe are the critical aspects of a certain phenomenon (Fredlund et al., 2015), but an object of learning needs to be carefully analysed in order for its critical aspects to be identified. Phenomenography offers a helpful tool to do this (Lo, 2012). To sum up, from a phenomenography and variation theory perspective, learning means discerning critical aspects of a phenomenon and being able to simultaneously focus on several critical aspects of an object of learning (Pang, 2003).

A consequence of learning being dependent on discerning new critical aspects of an object of learning, or making distinctions, is that a learner needs to experience contrast. Experiencing contrast is a foundational assumption in variation theory (Marton & Booth, 1997; Marton, 2015). Variation theory suggests that in order for students to develop a more complex understanding of the object of learning, teaching should be designed in a way that helps students to experience, or discern, the critical aspects of an object of learning (Lo, 2012; Marton, 2015; Åkerlind, 2005). This is preferably done by initially letting the aspects vary one at the time and finally simultaneously varying all aspects (Lo & Marton, 2011). One reason to why students sometimes do not learn what was intended could thus be that they focus on other aspects than the critical, that they cannot focus on all aspects simultaneously, or that the teaching did not manage to make the critical aspects discernible for the students (Mun Ling & Marton, 2011).
Phenomenography and variation theory in this thesis

Phenomenography and variation theory are used in Papers I and II to define learning, identify critical aspects and analyse data. In Paper I, phenomenography and variation theory are used to analyse students’ conceptions of causal relationships in pricing and relate the outcome space identified to other outcome spaces focusing on price. Paper II focuses on the discerning of different critical aspects of causality in pricing in relation to visual representation used in teaching. In both cases, learning is defined in phenomenographic/variation theory terms, i.e. a qualitative change in how a phenomenon is ‘seen’ or experienced, through the discernment of critical aspects of the object of learning.

Practice theory perspective

A practice theory perspective on knowledge and learning has had an impact in several different fields, such as philosophy (for instance Schatzki, 2001), sociology (for instance Knorr Cetina, 2001), and education (for instance Radford, 2015 and Lave & Wenger, 1991), resulting in several different directions of the practice theory perspective. Although those scholars address a practice theory perspective from partly different points of departure, they all contribute to understanding knowledge and learning from a practice perspective, which is why they are relevant for this thesis. I will in the following sections outline some foundational ideas in a practice theory perspective, based on ideas from the above-mentioned directions.

A practice theory perspective on knowledge and learning needs to be understood in light of the ‘practice turn’ (Schatzki, 2001), which developed as a response to the traditional rationalistic view on knowledge (Carlgren, 2011). With a rationalistic view, knowledge is seen as propositional and learning is seen as knowledge acquisition, a process contained in the mind, or in the heads of individuals. Further, mind and body are seen as a dichotomy (Lave, 1993; Lave & Wenger, 1991). In contrast, a practice theory perspective argues that knowledge is constituted in, and actualised through, people’s actions (Eriks-son & Lindberg, 2016; Knorr Cetina, 2007; Radford, 2015) and that learning should be considered a changed participation in social practices (Lave, 1993). Taking a practice theory perspective thus means “shifting the analytic focus from the individual as a learner to learning as participation in the social world, and from the concept of cognitive process to the more-encompassing view of social practice” (Lave & Wenger, 1991, p. 43).

A central idea in a practice theory perspective is that learning, understanding and meaning are defined relative to actional contexts, rather than self-contained structures (Lave & Wenger, 1991). In other words, practical activity, in which an object of knowledge is set in motion, is what makes learning possible (Radford, 2015, 2018). In that sense, learning could be considered “changing
understanding in practice” (Lave, 1993, p. 6). The idea of learning as increasing participation, which concerns a person acting in a practice, clearly contrasts to the idea of learning as internalization (Lave & Wenger, 1991). Schatzki states that “it is through action and interaction within practices that mind, rationality and knowledge are constituted” (Schatzki, 2001, p. 8). This implies that learning happens in a social practice (Lave, 1993) and that what learning is made possible depends on the specific practice, what kinds of actions and interaction are expected from the participants in the practice and what tools are involved. Knowledge is thus considered not an individual property, but “a feature of groups, together with their material setup” (Schatzki, 2001, p. 21). Participating in a practice thus opens up for practitioners to making the knowledge embedded in the practice their own (Eriksson, Arvola Orlander & Jedemark, 2008). ‘The practice’ could thus be seen as a theoretical entity (Lave, 1993) and is a good place to investigate phenomena such as knowledge (Schatzki, 2001). Classroom actions could therefore be considered useful units of analysis (Radford, 2018). From an activity theory perspective (Leont’ev, 1978), a practice can be defined by identifying what the actors want to accomplish, thus what is going on and why, and are realised through goal-oriented actions (Eriksson, Arvola Orlander & Jedemark, 2004; Eriksson & Lindberg, 2016).

Two practice-related terms are of special interest here (see Paper III): epistemic practice and teaching-learning practice. Epistemic practice is a concept introduced by Knorr Cetina (1999, 2001, 2005, 2007) and refers to practices where ‘knowledge production’ and learning are the main objects. Epistemic practices are thus characterised by developing and transforming knowledge required in a specific situation. In contrast, habitual practices are characterised by routine and tradition (Knorr Cetina, 2001). Knowledge is thus not developed and transformed in habitual practices as is the case in epistemic practices. If a practice is epistemic or not is not determined by where it is realised (for instance in school), but by what kinds of activities are established - whether or not knowledge is developed and transformed (Eriksson & Lindberg, 2016). This implies that teaching-learning actions within a practice can, depending on the goal of the actions, realise either an epistemic or a habitual practice. Kelly and colleagues (Kelly, Crawford & Green, 2001), as well as Radford (2015, 2018) suggest that epistemic activities are central to education.

The term teaching-learning practice is in this thesis used to refer to the practices established in the classroom during a lesson. Based on Eriksson and Lindberg’s (2016) definition of practice mentioned above, a teaching-learning practice could be defined by identifying what the teacher and students want to accomplish, thus what is going on and why in the teaching situation. Describing teaching-learning practices thus means describing the actions in the classroom (such as communicative actions) and the goals driving them. As the goals for different actions in the classroom can be very different, teaching-learning practices can be both epistemic and habitual. This implies that most
teaching situations, no matter how epistemic, also include well needed habitual elements. By identifying the characteristics of different teaching-learning practices, it is possible to identify what learning is facilitated through participation in these practices (Eriksson et al., 2008). How actions are formed is thereby related to what learning is made possible and what abilities can be developed (Radford, 2018).

Four central ideas

Four central ideas within a practice theory perspective are of special interest for this thesis. First, *an action is driven by its goal* (Wertsch, 1998, see also Leont’ev, 1978). This implies that actions are intentional and that any action thus can be characterised by identifying its goal. Two seemingly similar actions can have different goals and thus realise different practices. Similarly, two seemingly different actions can realise similar practices. Second, *classroom actions, including both teachers and students, is the unit of analysis, as participating in a practice is what makes learning possible* (Lave & Wenger, 1991; Radford, 2015, 2018). In that sense, a practice is identified through an analysis of the participants’ actions. It is through analysing the actions, as for example communicative actions (Wertsch, 1998), one can identify the goal of the action and thus identify the practice. Third, *the tools that are used and developed in the practice mediate the actions and contribute to forming the practice* (Schatzki, 2001; Wertsch, 1998). Tools, such as artefacts and models, are suggested to have a mediating function (Wertsch, 1998) in that different tools may facilitate, or afford, different actions and thus affect what is made possible for students to learn. Fourth, *participating in a certain practice facilitates the development of certain abilities and ways of knowing* (Lave & Wenger, 1991). This implies that the kind of practices students are invited to participate in is closely related to what abilities can be developed (Carlsgren, 2011; Radford, 2018). By discerning and describing different teaching-learning practices it is thus possible to identify what knowledge and abilities are made possible to develop in the different practices.

Visual representations in a practice theory perspective

As mentioned earlier, tools that are used and developed in a practice play a central role in forming the practice, as they have a mediating function for the actions (Schatzki, 2001; Wertsch, 1998). One kind of tools often used in teaching are models, aiming to grasp some of the central ideas or aspects of the phenomenon it illustrates or relates to (Eriksson, 2017). Being symbolic representations of a phenomenon or a system, models are commonly used as tools for problem solving (Van Dijk et al., 2003; Eriksson, 2017). In this thesis, models are focused upon in terms of visual representations. Ewenstein and Whyte (2009) suggest that visual representations are not peripheral to the epistemic work, but central to practices, as practitioners interact with those tools.
when they develop knowledge. Further, they suggest that visual representations can play an important role, not just by embedding and inscribing knowledge, but by generating questions and encouraging “wanting and unfolding in uncharted directions” (Ewenstein & Whyte, 2009, p. 22). However, this capacity to generate questions can also make the visual representations challenging and difficult to manage (Ewenstein & Whyte, 2009). The interaction between the practitioner and the tools used in the practice is expressed by Schöen (1983) in terms of “the evolution of knowledge taking place through a conversation with materials” (Schöen, 1983 in Ewenstein & Whyte, 2009, p. 9). Similarly, Radford (2018) considers artefacts as part of thinking.

**Characteristics of a visual representation as a tool**

Two characteristics of a visual representation as a tool in a practice are of specific relevance for this thesis: its *compositional structure* and its *partiality*. Those two characteristics will be highlighted in short below.

First, it has been suggested that the compositional structure of a visual representation, thus how a concept or phenomenon is visually illustrated and composed, matters for what learning is made possible, since how a visual representation is composed may affect meaning and facilitate different conceptions of the content illustrated (Danielsson & Selander, 2014; Kress, 2010; Kress & Van Leeuwen, 2006). It is thus argued that how a visual representation is composed is important for what aspects of the phenomenon/knowing are given primacy and thereby are made possible for students to discern/experience (Airey & Linder, 2009; Danielsson & Selander, 2014). In a similar manner, McDermott and colleagues (McDermott, Gardner, Greeno, Reif & Schoenfeld, 1990) suggest that different aspects of a concept are emphasised in different visual representations. The idea of different representations having different potentials for providing access to disciplinary knowledge has by some been identified as ‘affordances’ (Gibson, 1979; Gibson & Pick, 2000), or ‘disciplinary affordances’ of a visual representation (Airey, Eriksson, Fredlund & Linder, 2014; Fredlund et al., 2012). This notion implies that different representations of the same phenomenon may “provide access to different disciplinary-relevant aspects” (Fredlund et al., 2012, p. 658) and that different aspects of the content may be possible to discern/experience through different visual representations. Airey and Linder (2017) relate the notion of ‘disciplinary affordance’ to the notion of ‘pedagogical affordance’. The former refers to “the agreed meaning making functions that a semiotic resource fulfils for a particular disciplinary community” (Airey & Linder, 2017, p. 106) and the latter refers to how useful a certain visual representation tends to be for teaching and learning a specific content (Airey & Linder, 2017). The authors further argue that an issue to pay attention to is whether or not a student’s experience of a certain semiotic resource, such as a visual representation, ‘corresponds’ with the disciplinary affordance, thus its disciplinary meaning potential.
Second, one of the challenges with visual representations is that they are partial in nature (Kress, 2003; Fredlund, Linder, Airey & Linder, 2014). Fredlund and colleagues (2014) suggest that this partiality has two components. First, any single representation is limited in terms of the meaning it can convey and illustrate (Airey & Linder, 2009; Kress, 2003). Second, representations are often being ‘disciplinary rationalised’ (Halliday & Martin, 2003; Fredlund et al., 2014). This means that some aspects are implicit in the visual representation. In other words, some parts of the intended meaning are not explicitly illustrated and therefore not immediately discernible (Fredlund et al., 2014). This rationalization could be considered very constructive for communicating within the discipline and between experts. However, for students who have not yet discerned the important aspects that lie beyond what is explicitly visualised in the representation, this rationalization may cause problems in the learning situation (Fredlund et al., 2014). It may be that some foundational aspects of a certain phenomenon are taken for granted and therefore have been rationalised out of a visual representation (Fredlund et al., 2014). One of the challenges in teaching thus lies in creating possibilities for ‘de-rationalizing’ or ‘unpacking’ the visual representations used, so that students can discern also the more implicit aspects in the visual representation used in a teaching and learning situation (Fredlund et al., 2014).

With this background, a visual representation is in this thesis, as mentioned earlier, defined as “a model that represents a phenomenon, situation or construct (or parts of them) in a particular way, namely bringing certain aspects of the phenomenon, situation or construct to the fore while allowing other aspects to recede into the background” (Ingerman et al., 2009, p. 3). This definition of a visual representation implies that it is important to note what aspects of the knowing is communicated, placed in foreground versus background and made possible to discern, when using visual representations in teaching and learning. It also implies that visual representations are partial in nature and that creating visual representations in a subject is a theoretical work, as it includes deciding what relations and concepts (in social science often abstract) to highlight and how. This touches upon a more philosophical question concerning whether it is even possible to separate form from content (Danielsson & Selander, 2014). It may be that the design of a visual representation is not determinant for how a specialist within a field, who has already discerned different aspects of the concept or phenomenon, understands it, but that the design is of great importance for a novice in the field (Airey & Linder, 2009; Danielsson & Selander, 2014). Consequently, it is of great importance to investigate what knowing/learning/actions different visual representations ‘afford’, in order to develop a deepened and more complex understanding of the phenomenon or concept in focus.
Practice theory perspective in this thesis

A practice theory perspective is used in Paper III to define learning and analyse data, in terms of identifying the participants’ actions, the goals driving them, as well as the practices established when different tools (visual representations) are used in the classroom. The results are discussed in terms of teaching-learning practices established, as well as to what extent those practices could be considered epistemic or not. The role of the compositional structure of a visual representation is focused in Paper II, where students’ developed conceptions of causality in pricing are analysed. Differences between the visual representations are discussed in terms of aspects placed in the background versus foreground as well as rationalization and aspects made implicit and explicit.
5. Methods

Three framings: design research, clinical research and practice development research

This thesis investigates how visual representations can facilitate learning of dynamic interrelations in social science teaching. It examines the role that compositional structure of a visual representation plays in developing students’ conceptions of causality in pricing, using phenomenography and variation theory, and how different visual representations of the same subject content (pricing in economics) may relate to the teaching-learning practices established in the classroom, using a practice theory perspective. It focuses on teaching and learning of a particular content in a classroom-setting, focusing on the design of the teaching in terms of the design of the visual representation used. This section focuses on the research traditions that are drawn upon in the design and analysis of interventions to promote learning through the use of visual representations.

The studies in this thesis could be understood in relation to three different research framings. First, they could be understood in relation to a design research tradition (Brown, 1992; Collins, 1992), as the use of a particular visual representation in teaching could be considered a teaching design. From this perspective, the research questions in two of the papers (Papers II and III) focus on the relationship between students’ learning and the design of the visual representation (i.e. the teaching design). Design research could be understood as one of several different research approaches that have emerged within educational research aiming at developing the practice of education in collaboration with the professionals in schools. Van den Akker (1999) suggested ‘development and design research’ as an umbrella term for many of the different research approaches of this kind (where action research (Stenhouse, 1981; Elliot 1991), lesson study (Fernandez, 2002) and learning study (Pang & Marton, 2003) are other approaches). The design research tradition was developed in order to address different issues concerning the study of learning, such as the need to study learning in real-world settings rather than in a laboratory, to extend measures of learning and to address theoretical questions about the nature of learning (Collins, Joseph & Bielaczyc, 2004). Design research is conducted as a collaboration between researchers and practitioners, with the aim to develop practice as well as theories about learning and the design used to support that learning (Carlgren, 2012; Cobb, Confrey, DiSessa,
Lehrer & Schauble, 2003). Cobb and colleagues (2003, p. 11) summarize the core of design research in saying that "most classroom design experiments are conceptualised as cases of the process of supporting groups of students’ learning in a particular content domain. The theoretical intent, therefore, is to identify and account for successive patterns in student thinking by relating these patterns to the means by which their development was supported and organised."

The core of what is stated in Cobb’s (2003) summary of design experiments above applies to my studies: the intent of supporting learning in a particular content domain and the intent to relate student learning to the means by which this learning was supported. The three studies are also conducted in a real-world setting, they use different measures of learning, are conducted in collaboration with teachers and aim at contributing to both theory and practice. However, a couple of features of the design research tradition are not applicable in the studies presented in this thesis. First, in design research there is generally a focus on finding a successful and effective design and to revise the design until "all the bugs are worked out" (Cobb et al., 2003; Collins et al., 2004, p. 19). In the studies presented in this thesis, the aim was not to find the perfect design, but to further understand learning in light of a certain design. The studies focus on ‘how classroom practices operate’, rather than simply asking ‘do they work?’. The complexity of the real-world setting is accepted as unavoidable in this thesis. It is thus not seen as a problem in my research, as in much of the design research (Collins et al., 2004). Also, in design research the teachers are very much involved in the research process, but as practitioners rather than co-researchers, as elements in the designed context rather than professional actors (Carlgren, 2012). Collins and colleagues (2004, p. 17) conclude that "the goals and principles underlying the design are undermined by the way the design is enacted”, which implies a view on teachers as potentially hindering the development of a design rather than making it possible. In the research presented in this thesis, the teachers involved are considered more than merely practitioners carrying out a teaching design, in that they are also involved in the research process, for instance through planning the intervention.

A second way of framing this thesis is to use Carlgren’s (2012) term ‘clinical research’, which can be described as "research aimed at improving educational practices by generating knowledge in connection with teachers’ professional tasks and objects. Such knowledge is generated in dynamic, interpretative and meaning-making practices and is intended for use in other dynamic interpretative and meaning-making practices” (Carlgren, 2012, p. 134). A defining feature for this approach is its strong emphasis on teachers as actors in the research process rather than objects for the research. The overlapping role of the researcher and the professional is central as professional skills are considered necessary of the research process. Also, focus is on the knowledge-
producing activity where professional tasks are of interest, not the professionals (as is the case in for instance teacher research) (Carlgren, 2012). This applies to the research conducted in the realm of this thesis.

Third, in a broader sense, this thesis could be understood in relation to a practice development research approach, a research approach focusing on practice development, investigating questions originating from the profession. In the practice development research tradition, a focus on the ‘real-world-setting’ implies that teaching and learning is studied in the practice, where a specific subject content is learnt, rather than studying teaching and learning from a more general perspective (Wang & Hannafin, 2005). Studies conducted within this approach are often conducted in collaboration with teachers and could be defined as research in education as compared to research on education (Stenhouse, 1981). Although the design of the studies included in this thesis is not iterative, which is often the case within this approach, the studies are carried out in collaboration with teachers, they are intervening, they aim to contribute to both practice and theory and the questions raised concerning challenges in teaching and learning about pricing through visual representations also stem from the profession.

The studies presented in this thesis compare groups with teaching interventions based on different visual representations, thus where the teaching design differs. Given what has been presented above, this thesis could thus be understood as a collaborative semi-experimental clinical design study, aiming at developing practice as well as theory.

Object of research

The object of research in this thesis is the relationship between learning and the visual representation used in teaching. The theoretical outset is partly different in the separate papers included (a phenomenography and variation theory perspective in Papers I and II and a practice theory perspective in Paper III), which causes learning to be defined partly different in the separate papers. However, it is still the relationship between learning and the visual representation that is in focus in the different studies. A phenomenography and variation theory perspective provides a way of investigating change in students’ conceptions of pricing when different visual representations are used in teaching. A practice theory perspective is used to investigate the teaching-learning practices established when teachers used different visual representations. The focus of attention differs between the separate studies (being on students’ developed conception of the content in light of the visual representation used in teaching in Paper II and on the relation between the design of the visual representation and the teaching-learning practices established in Paper III), but the object of research is still the relationship between learning and the visual representation used.
Research design and procedure

Design of the studies

In order to investigate how different visual representations of the same subject content (pricing in economics) contribute to a complex understanding of the content visualised and relate to the teaching-learning practices established, the research design needed to make possible a comparison between teaching and learning through one or the other of two visual representations. An intervention consisting of three introductory lessons on pricing was conducted with four different upper secondary classes (see Figure 4). Each group had the intervention based on one of two visual representations of pricing (see Figures 5 and 6).

![Diagram](image)

*Figure 4. Design of the study.*

Participating schools, teachers and students

Four classes from two different upper secondary schools participated in the study. Both schools were situated in the Stockholm region, and both had diverse catchment areas. The schools were chosen as they were similar in terms of student population and as I had contacts with teachers from those schools, willing to participate in the project. Three teachers were involved in the study and taught their own classes as part of their regular social science teaching. Two teachers taught one class each and one teacher taught two classes. The
teachers were also involved in planning the intervention. One of the teachers was involved in the planning from the very beginning, whereas the other two were engaged in the later stages of planning the lesson sequence.

In all, 94 students, of which 36 were boys and 58 were girls, aged 16-18 years, participated in the study. An additional three students chose not to participate. All students took the course social science, which includes an introduction to economics and personal finance.

Materials

The material used were of three different kinds: (i) visual representations of pricing on which the lessons were based, (ii) questions answered individually and in writing (pre- and post-test questions) and (iii) questions discussed in groups of three to five students as part the research lesson.

Visual representations of pricing

Two different visual representations of pricing were used and compared in this work. Both diagrams illustrated the relationships between supply, demand and price. One of the representations was a supply/demand graph (see Figure 5). The other was a causal loop diagram (see Figure 6). The loop diagram was slightly modified from Wheat’s original loop diagram (Wheat 2007a, p. 369) in order to make it more accessible for upper secondary students. Signs for delayed effects were excluded and red arrows illustrating how the different variables correlate with each other were added. Supply/demand graphs are commonly used in teaching economics, whereas the causal loop diagram is less commonly used. It was created in order to help students grasp the dynamic processes in pricing (Wheat, 2007b).

Both visual representations are developed within an economics discipline (one in economics and one in system dynamics) and both illustrate the dynamic relationships between supply, demand and price, however, they differ in terms of compositional structure. The supply/demand graph illustrates causality implicitly through the curves and how they relate to each other. The causal loop diagram illustrates causality more directly through arrows connecting supply, price and demand. The mathematical underpinning of the graph enables analysis of the size of the changes, whilst the loop diagram focuses on the causal relationships. Both representations introduce the same terms: supply, demand and price (although with the term ‘quantity’ also being introduced through the graph).
Students’ understanding of causal relationships in pricing before and after teaching with each visual representation was assessed through two questions which were used in a pre-test and a post-test:

1. Over the last decade there has been a significant increase in film downloads. What effects may this have on the price of movie tickets at Stockholm cinemas and why? Reason and give arguments for your answer and use both words and a diagram to explain your thoughts.

2. Over the last years, the demand for ecological hamburgers has increased as a result of a greater concern for the environment. What effects will this have on the price of ecological as well as...
non-ecological hamburgers and why? Reason and give arguments for your answer and use both words and a diagram to explain your thoughts.

As ideas on pricing may vary across different products (Ignell et al., 2017), the questions used involved different products. Open response questions were preferred rather than multiple choice items in order to avoid imposing an incomplete pre-determined set of alternatives and in order to identify students’ conceptions of the content in focus as expressed by the students themselves. The questions were piloted before the actual study in order to ensure that students understood and engaged with the questions and that the questions enabled the students to discuss and elaborate on the concept of pricing. Eight of the students in the pilot study were also interviewed concerning the questions in order to further investigate the questions’ levels of intelligibility and difficulty. Results from the pilot study showed that the questions created good opportunities for students to express their understanding of relationships between supply, price and demand. Some small language adjustments were made on the basis of the pilot study (e.g. ‘environmental friendly’/‘non-environmental friendly’ to ‘ecological’/‘non-ecological’).

**Questions for small group discussions**

Two questions were formulated and used in small group discussions as part of one of the research lessons. One question focused on price of a new, and demanded, film service (Q1) and one on effects on milk prices if there was a change in supply (Q2):

1. Spotify has become a well used digital music service, supplying music to its customers. What has yet not been developed, but requested, is a similar streaming service for film. If such a service were to be developed and launched, what factors would affect the pricing of this service and why? Reason and give arguments for your answer.

2. During many years, one company was supplying most of the milk being sold in Swedish grocery stores. Lately, more companies have been entering the milk market. What will happen to the milk market and prices of milk if more suppliers are entering the market and why? Reason and give arguments for your answer.

The questions were formulated in order to create possibilities for the students to elaborate on the causal relationships between supply, price and demand. To further enable and encourage diverse and rich small group discussions, one of the questions placed demand in the foreground (Q1) and one placed supply in the foreground (Q2). The questions were previously piloted with 30 students.
not included in the main study, in order to check if students understood and engaged with the questions and to what extent the questions opened up for the discussions intended. Eight students from the pilot study also volunteered for follow-up interviews, conducted in order to further explore the students’ understanding of, and reactions to, the questions. Results from the pilot study confirmed the formulation and use of the questions.

Research data
Three kinds of research data were collected and analysed: (i) students’ written answers to pre- and post-test questions, (ii) transcriptions of the research lessons, including the teacher’s introductory lecture on pricing, and students’ comments and questions during this introduction and (iii) transcriptions of small group discussions (see Figure 7 and Table 2). Paper I used students’ written answers in the pre- and post-tests to examine students’ conceptions of the causal relationships in pricing. Paper II analysed the same data to examine how the development of students’ conceptions of causality in pricing was affected by the choice of visual representations. Paper III focused on the relationship between the visual representation used in teaching and teaching-learning practices established in the classroom and was based on transcriptions of research lessons and small group discussions (see Figure 7 and Table 2).

Figure 7. Research data in focus for the different papers.
Table 2. Data used in the three papers included in the thesis.

<table>
<thead>
<tr>
<th>Paper</th>
<th>Data used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper I</td>
<td>328 written student answers</td>
</tr>
<tr>
<td>Paper II</td>
<td>280 written student answers (140 from pre- and post-test respectively)*</td>
</tr>
<tr>
<td>Paper III</td>
<td>8 transcribed lessons (320 min)</td>
</tr>
<tr>
<td></td>
<td>21 small group discussions (210 min)</td>
</tr>
</tbody>
</table>

* 48 student answers were excluded from the analysis in Paper II, which explains the 280 answers analysed in Paper II compared to the 328 in Paper I. The exclusion of answers was due to some students only answering the pre-test questions, thus not answering the post-test questions. In cases where a post-test answer was missing, the pre-test answer from this student was removed from the analysis, as both pre- and post-test answers were needed in order to analyse change in a student’s conception of pricing.

Lesson design and procedure

The lesson sequence consisted of three lessons (see Table 3) that were all filmed. Before the lesson, all students answered the two pre-test questions individually in writing in order to investigate their conceptions of the subject content before the lesson sequence. During research lesson 1 an introductory lecture was given on pricing and perfect competitive market and the teacher explained the relationship between supply, price and demand by using one of the two visual representations (the graph in two classes and the causal loop diagram in two classes). In all classes the explanation was built up by drawing the representation (graph or causal loop diagram) step by step on the whiteboard while explaining.

Research lesson 2 started with a short re-cap of what was discussed during the previous lesson. Students were then asked to answer one of the pre-test questions (Q2) individually and in writing. Students were then divided into smaller groups of three to five students and were given a sheet of paper with the two group discussion questions (see above) together with the visual representation presented during the introductory lecture. The groups were encouraged to use the visual representation in their discussions. The small groups were given a maximum of 15 minutes for their discussion and the discussions lasted between 6-14 minutes, with a mean length of ten minutes. All small group discussions were filmed and transcribed. The two questions discussed in the small groups were then discussed and summarised in class at the end of the lesson.

During research lesson 3, classes that had lessons based on the causal loop diagram were briefly introduced to the graph, and how it could be understood in relation to the causal loop diagram, as it was considered important that the
students at least were introduced to the graph, being a commonly used illustration within the discipline. Classes that had lessons based on graphs were further discussing graphs with a focus on changes in supply and demand. Finally, the students answered individually and in writing the second of the pre-test questions (Q1).

There were two reasons why the graph groups were not in a similar way introduced to the causal loop diagram at the end of their intervention. First, the aim was not to investigate if the order of introducing different visual representations of the same content mattered for developing a qualified way of understanding the causal relationships in pricing. Second, the aim was to compare a causal loop diagram intervention with an intervention designed as an average introductory lesson sequence on pricing in an upper secondary social science classroom, which traditionally includes graphs, but not a causal loop diagram. One could then argue that a potential difference in results between the causal loop diagram-based groups and the graph-based groups would be due to the fact the former were introduced to two different visual representations rather than one. However, the post-test results for Q1 and Q2 (assessed during lesson 3 and 2 respectively) were very similar. There was even a tendency towards a bit less qualified answers in the answers to Q1 compared to Q2 in the loop diagram group (although not statistically significant), which was answered after the brief introduction of the graph (thus at the end of lesson 3). Introducing supply/demand graphs to the loop diagram group could thus not explain a potential difference in results between the two groups. The rationale for letting students answer post-test questions 1 and 2 at different occasions (one during lesson 2 and one during lesson 3) was to ensure that potential differences between the groups did not depend on the causal loop group being briefly introduced to the supply/demand graph.

The lesson plan was the same in all classes (see Table 3) and the teachers started off with the same products when exemplifying different aspects of the relationships in pricing, although different products were introduced in dialogue with the students.
Table 3. Overview of research lessons 1-3: content focused upon and examples used in research lessons with the supply/demand group and causal loop diagram group, respectively. Differences between the groups are shown in italics.

<table>
<thead>
<tr>
<th>Research lesson</th>
<th>Supply/demand graph group</th>
<th>Causal loop diagram group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test Q1 and Q2 before lesson 1</td>
<td></td>
</tr>
<tr>
<td>Lesson 1: Content</td>
<td>Introduction to pricing and perfect competitive market by drawing three supply/demand graphs on the whiteboard (showing (i) supply logic, (ii) demand logic and (iii) reciprocal relationship between demand and supply resulting in price)</td>
<td>Introduction to pricing and perfect competitive market by drawing the causal loop diagram on the whiteboard</td>
</tr>
<tr>
<td>Lesson 2: Content</td>
<td>Re-cap of the introduction to pricing by drawing the graphs on the whiteboard. Small group discussions followed up by discussion in class</td>
<td>Re-cap of the introduction to pricing by drawing the causal loop diagram on the whiteboard. Small group discussions followed up by discussion in class</td>
</tr>
<tr>
<td></td>
<td>Post-test Q2 (as part of lesson 2)</td>
<td></td>
</tr>
<tr>
<td>Lesson 3: Content</td>
<td>Elaborating on the effect of change in supply and demand on price</td>
<td>Introducing the graph in light of the causal loop diagram</td>
</tr>
<tr>
<td></td>
<td>Post-test Q1 (after lesson 3)</td>
<td></td>
</tr>
</tbody>
</table>

Data analysis

Three main methods were used to analyse the data: (i) phenomenography in combination with variation theory, in order to identify students’ different conceptions of the causal relationships in pricing and critical aspects necessary for students to discern, (ii) quantitative analysis, in order to identify the differences and magnitude in students’ developed conceptual understanding in relation to visual representation used in teaching and (iii) practice theory-oriented analysis, in order to identify teaching-learning practices established in lessons and small group discussions.

Analysis of students’ conceptions of the causal relationships in pricing

In order to analyse students’ conceptions of the causal relationships in pricing, the analysis followed the conventions of phenomenography and variation theory (Papers I and II) (Marton, 1981, 2015; Marton & Booth, 1997; Åkerlind,
This analysis focused on identifying qualitatively different conceptions/ways of seeing/experiencing/understanding the causal relationships in pricing, as well as critical aspects necessary for students to discern in order to develop a more complex conception of the phenomenon. A fundamental distinction in phenomenography is that between a first-order and a second-order perspective (Marton, 1981). While a first-order perspective identifies various phenomena, a second-order perspective aims at describing how people experience those phenomena (Marton, 1981). This is identified by analysing and interpreting individuals’ ways of expressing themselves in relation to a certain phenomenon. Here, students’ written answers to pre- and post-test questions concerning pricing were analysed, thus their way of experiencing the causal relationships in pricing as expressed in written answers. In a phenomenographic analysis, the data analysed often consists of recorded and transcribed interviews. However, several studies also base their analysis on written material (see, for instance, Johansson, 2019; Thorsten, 2017; Tväråna, 2019).

The phenomenographic analysis was conducted in several steps. First, the material was read as a whole and students’ written answers were analysed in terms of what the students were talking about when they were talking (in writing) about the phenomenon investigated (causal relationships in pricing). Second, students’ expressions were analysed as expressions of qualitatively different ways of experiencing/seeing the phenomenon in focus. Those different ways of experiencing/seeing the phenomenon were categorised into categories of descriptions, or conceptions. The categories/conceptions are a theoretical construction, constructed by the researcher, in order to grasp how the students relate to the phenomenon (Marton, 2015). All student answers were thus categorised to the different categories of description. In this process those categories were partly revised. The different categories of descriptions, or conceptions, that emerged were then organised in a hierarchy, an outcome space, where a more complex conception is contrasted with less complex conceptions. The most qualified conception withholding the most differentiated experiencing of the phenomenon. Finally, based on the notion of ‘critical aspects’ in variation theory (Björkholm, 2015), aspects of the phenomenon that need to be discerned in order to develop a more qualified conception of the phenomenon were identified.

Phenomenographic analysis accepts that it is possible for one student to express more than one way of understanding the relationships in pricing, placing different parts of their response in different categories of conceptions (Marton, 2015). A subsample (10%) of students’ responses were independently analysed by two researchers who then compared and discussed their interpretations of the data. A reliability analysis of researchers’ application of the agreed categories was high (r = .94)
Analysis of students’ developed conceptual understanding of causality in pricing in relation to visual representations used in teaching

The analysis of students’ understanding of causality in pricing in relation to the visual representation used in teaching used quantitative and qualitative methods (Paper II). Quantitative methods were used to identify how students’ conceptions changed between the pre-test and the post-test. The difference in change between the two groups (using the two diagrams) was analysed using t-tests and effect sizes (Cohen’s d). A mean value for the pre- and post-test respectively was calculated on a group level, for the graph group and the causal loop diagram group. More specifically, what was compared through the t-tests was (i) pre-test means, (ii) post-test means and (iii) change between post-test and pre-test means for the two groups (causal loop diagram group and graph group). Descriptive analyses were also conducted on an individual level, identifying how each student’s conception changed between the pre-test and the post-test.

Qualitative methods of analysis were used in order to further unfold the results from the quantitative analysis mentioned above. Quantitative differences in results between the graph group and the causal loop diagram group were thus related to the critical aspects identified and highlighted in the phenomenographic outcome space (originally presented in Paper I). This was done in terms of identifying what critical aspects of the causal relationships in pricing seemed to be discerned by the students through the use of the two different visual representations. The analysis identified what in the compositional structure of the two visual representations that may have affected whether students discerned a certain critical aspect or not. Also, examples of students having discerned a certain critical aspect during the intervention were identified.

Analysis of teaching-learning practices established

Transcriptions from the introductory lecture as well as from the small group discussions were analysed, using practice theory-oriented analysis to identify teaching-learning practices established in the classrooms (Paper III). A fundamental idea in a practice theory perspective is that knowledge is constituted in, and actualised through, people’s actions (Radford, 2015). Therefore, this analysis focused on identifying students’ and teachers’ communicative actions and the goals driving these actions. This was done by reading the transcriptions in the light of two questions: (i) What do the teachers and students do/communicate? and (ii) What are the participants trying to accomplish through their actions? For example, a student may ask a teacher why a detail in an illustration looks as it does and they may ask this in order to clarify the logics of the representations. Teachers’ and students’ communicative actions were also related to each other in order to investigate if some teacher actions encouraged certain student actions. Goals, actions and visual tools mediating
those actions (graphs and causal loop diagram) were analysed in order to identify teaching-learning practices established in the introductory lecture. Similarly, students’ communicative actions during small groups discussions were related to their understanding of the role of the visual representation. The communicative actions were analysed in terms of the goals driving them and in relation to the visual tool used in the lecture (graphs and causal loop diagram) in order to identify teaching-learning practices established in the introductory lecture and the small group discussions.

Quality criteria and knowledge claim

Validity

Validity deals with questions of credibility and whether what is being measured matches the intentions of the study. This aspect was partly accounted for in the studies conducted as part of this thesis, through piloting the questions used in pre- and post-test, as well as the questions discussed in small groups, as described above (see the “Materials” section). The qualitative analysis in Paper I provides the claim to validity in the quantitative comparison in Paper II. In Paper II and III there is no intention to strip away all but one key variable, which is often thought of as a key aspect in validity. In much of design and development research it is neither possible nor desirable to isolate, measure and manipulate separate variables in the same study (Van den Akker, 1999). On the contrary, Van den Akker (1999, p. 11) suggests that “it is the very nature of formative research to investigate comprehensive interventions that deal with many interrelated elements at the same time.” The intention in Paper II and III was thus rather to include the complexities of a teaching and learning situation. However, this aspect of validity is not straight forward.

Therefore, in the quantitative comparison (Paper II) it was important that students’ pre-understanding in the two groups did not differ significantly. If either group was significantly more advanced in the t-test, this could have indicated either of two problems: (i) one group had less potential to benefit from the intervention (ceiling effect); or (ii) one group was generally quicker to learn. The analysis of the pre-tests showed that the groups did not differ in terms of pre-understanding of the causal relationships in pricing.

Nevertheless, it is possible that potential different outcomes for students in the two groups could have been due to differences between the teachers. To minimize the risk of the individual teacher being the reason for the differences between the groups, all teachers followed the same lesson plan. Moreover, one teacher taught two groups: one graph and one causal loop diagram. The change in conceptions of these two groups with the same teacher provided a check on the overall results. However, future studies should aim to replicate these findings, preferably with a design where all involved teachers teach two classes each. It is also possible that potential different outcomes for students
in the two groups could have been due to factors outside of school, such as students learning about pricing outside of school, between the different lessons included in the intervention, for instance through media or students searching for information themselves. However, all classes had their intervention during the same time period and were thus subject to similar current news (although questions of pricing were not particularly highlighted in news or media during this period). Also, the pattern of students’ performance on pre- and post-tests were similar in groups having the intervention based on the same visual representation and there was thus no indication that students in one particular group developed their understanding of pricing between the lessons more than in any other group. In addition, getting a good grade was not an incitement for students to study pricing outside of school during this period, as the tasks included in the intervention were not graded by the teacher.

There were also two ways in which the qualitative analysis of behaviour in the lesson provides a basis for confidence in the validity of the quantitative comparison. First, the students were informed that the data collected during the research lessons would not be used by the teachers to grade the students. This decision was based on ethical grounds, as will be further discussed in the “Ethical aspects” section below. It cannot be ruled out that the material collected was affected by the fact that students knew that what they wrote would not be graded. It could be that the students did not put as much effort into answering the questions, and discussing the questions in small groups, as they would have done if they knew that their work would be graded. On the other hand, it could be that the students felt more free to express uncertainties and questions when they knew that what they expressed would not affect their grades. To reduce the negative risk of the material not being graded by the teacher, the students were explicitly asked to write as much and elaborated as they could when they answered the questions in writing. The recordings of the small group discussions revealed that the students focused on the task although it was not graded.

Second, the group climate, in terms of how safe the students felt to ask questions, express uncertainties, engage in small group discussions etc, could have differed in the four classes involved, something which was not controlled for. If the group climate differed, this may have affected the results in terms of students not having developed their conception of causality in pricing as much, independent of what visual representations was being used in the intervention. However, as the pattern was similar in both groups using the same visual representations (in terms of distribution of answers to the different conception of causality in pricing as expressed in pre- and post-tests and in terms of communicative actions afforded in the introduction lecture and small group discussions), this does not seem to have been an issue affecting the results.

In addition to the aspects of validity discussed above, thus the risk of other variables than the intended affecting the results, other aspects of validity should also be considered. One such aspect concerns how learning can be measured. Measuring learning is complex and inevitably a challenge. We can
measure signs of learning through what students say or do, through their words and actions. However, we do not know if this always mirrors their actual understanding of the subject content in focus. Also, it is difficult to determine if what students say or do actually mirrors a genuine understanding of the content in focus or whether what they say is merely a result of having memorized the right way to answer a certain question (Andersson, 1999), a phenomenon that for instance has been discussed in terms students using ‘learning slogans’ (DiSessa, 1993) or applying ‘discourse imitation’ (Airey & Linder, 2009). And if this is the case, could this be considered learning or not? How learning is operationalised and what signs of learning one looks for in the analysis will accordingly be of importance for the validity of the study. In this thesis, learning is defined and operationalised as developing more nuanced ways of seeing/experiencing a phenomenon, that is discerning more aspects of the learning object (Papers I and II), and as increasing participation in different practices (Lave & Wenger, 1991), identified through communicative actions and the goals driving them (Paper III). The development of students’ conceptions of causal relationships in pricing, as expressed in their written answers to questions, and their communicative actions in group discussions and in the teaching situation in general, are used as signs of this learning. Through using more than one way of measuring student learning (in this case using both students’ written answers to questions and students’ communicative actions in small group discussions and during lessons), the possibility of grasping student understanding and student learning may increase compared to using only one way of measuring.

Validity can also be considered in terms of accuracy. A way of strengthening this aspect of validity is to describe in detail the process of material collection, the process of participant selection and the process of analysis. For the studies included in this thesis, these processes are described in more detail above, as well as in section 6 and in most detail in the separate papers.

Newton and Burgees (2008) suggest different aspects of validity in relation to action research and suggest in line with Van den Akker (1999) that dependent on the mode of research and the purpose of the study, different aspects of validity will be emphasised. In relation to this thesis, two of the aspects of validity suggested by Newton and Burgees (2008) are especially interesting, namely outcome validity and process validity. The former deals with the extent to which the outcome of the research matches the intended purposes of the research and the latter with the efficacy of the research approach in addressing the research problems. I would argue that both outcome validity and process validity is good in the studies presented, as the findings are in line with what was intended with the studies and the methods used to address the research questions raised are relevant and applicable.

The authenticity of the research is enhanced by the involvement of teachers in the design process and the collaboration between teachers and the researcher in enacting this research (Carlgren, 2017). In the present study, there is a collaboration between the researcher and the teachers, and the research
questions stem from both research and classroom practice. I conducted the analysis, but one of the teachers was involved in step two, when a suggested outcome space was to be validated, tested and discussed.

Reliability
Reliability concerns whether measurement is carried out in a fair, genuine and replicable way and deals with authenticity, trustworthiness, solidity and accuracy. Being systematic in the research process thus plays a key role here. In order to enable a critical analysis of the solidity and accuracy in the studies, the process of participant selection, collecting material and analysing material is described in detail (see above and in the separate papers).

Analysis of material collected inevitably involves subjective interpretations of the researcher. For instance, in a phenomenographic analysis, the researcher analyses and interprets the material and selects quotes to exemplify different ways of seeing or understanding a phenomenon. Similarly, in an analysis of teaching-learning practices, students’ and teachers’ communicative actions are identified as well as the goals driving them. It could not be ruled out that the material, if analysed by another researcher, would result in a partly different analysis/outcome space. One way of dealing with this challenge and thereby further assure the solidity of the analysis and results, is to let a co-researcher analyse the material in the light of a suggested outcome space (inter-rater reliability). In order to ensure the solidity of the analyses and phenomenographic outcome space in this thesis, the material was analysed by a co-researcher and the outcome space was discussed and revised in cooperation with several co-researchers. Similarly, the identification and categorisation of teachers’ and students’ communicative actions were discussed and revised in cooperation with other co-researchers.

Also, the solidity of for instance a phenomenographic outcome space, could be further ensured through separate phenomenographic analyses of pre- and post-tests, rather than using the outcome space from the pre-test to analyse the post-test. In analysing the post-test material anew, there is a possibility for new aspects to be found, more nuances to be detected and a specifying of critical aspects to be identified. In the present studies, the material of pre- and post-test were analysed through separate phenomenographic analyses.

Generalisability
Generalisability is often thought of as based on strict sampling from a population. This is not applicable in much qualitative educational development research (Larsson, 2009; Van den Akker, 1999). As for validity and reliability, different kinds of research require different lines of reasoning concerning generalisability and it has been argued that we need more nuanced meanings of the concept of generalisation in order to address different generalisation problems (Larsson, 2009). Design and development research is often rather context bound and does often not strive towards context-free generalisations (Carlgren
2012), however other forms of generalisations may well be useful. Although statistical generalisations are often not applicable, analytical generalisations may well be (Carlgren, 2012). A key question when it comes to generalisability in qualitative research approaches is: generalisation in relation to what? Three possible answers to that question is (i) in relation to other contexts, (ii) in relation to theory, and (iii) in relation to the case/object of learning itself.

A rather common idea in qualitative research is that generalisability should be considered in relation to other contexts. With this approach, generalisability is considered in terms of transferability (Denzin & Lincoln, 1994) with a focus on for whom, under what circumstances and in what contexts the results could be transferable. In the final chapter of this thesis, these aspects of generalisability are discussed in terms of relevance for social science education in general. Results presented in this thesis are thus suggested to be transferable to a more general context than economics teaching and learning about causality in pricing. These generalisations are also formulated as a number of practical implications for teaching (see Chapter 8). However, there are several challenges with this type of generalisation. Deciding what other contexts the findings of a study could be transferred to is often not an easy task. When are for instance two contexts similar enough for transferability of the findings? Another challenge with generalisation to context is that such generalisation presupposes that the context determines the phenomenon (Larsson, 2009), which may not be the case. Van den Akker (1999) suggests that one could talk about an analytical form of generalisability where the readers themselves transfer the research findings and decide what kind of generalisations can be made to their own contexts.

Generalisability could also be considered in relation to theory. Stiles (2009) argues when discussing generalisability in relation to case studies, that it is the theory that bear the whole burden of generalising, not the case. As case observations in a study are often few, they cannot be generalised themselves, but theory derived from case observations can be generalised. By analysing specific teaching and learning situations in relation to a theory, more general aspects of the particular situation are being focused upon (Carlgren, 2017). This thesis offers new insights concerning student conceptions of the relationships in pricing, as well as insights into the relationship between the visual representation used in teaching and teaching-learning practices established in the classroom. It thus contributes to theory and can be generalised in that sense.

A third way of arguing concerning generalisability in qualitative research approaches is generalisability in relation to the case or the object of learning itself. One way of framing this is to contrast generalisation to specification (Carlgren, 2012; Dewey & Bentley, 1960). Where generalisation per se considers a wider context, specification is about discerning more and more aspects of a phenomena studied (Carlgren, 2012). The idea here is that by digging deeper in the particular, one can get at the universal. Carlgren (2012, p. 134)
suggests that “by discerning more and more aspects, knowledge/meaning becomes more specific and nuanced, leading to precise implications for design. It is a meaning making process where the meaning making gradually becomes more differentiated.” If many qualitatively different views on something can be grasped, for instance in a phenomenographic analysis where focus is on describing variation in ways of seeing and understanding a phenomenon, generalisability enhances (Larsson, 2009). In that sense a specification in itself means an enhanced generalisation at the same time as specification is something rather different from generalisation. Results presented in this thesis contribute with a specification in terms of identifying students’ conceptions of causality in pricing as well as aspects critical for students to discern in order to develop more qualified and nuanced conceptions of causality in pricing. Results presented also contribute with specification in terms of what aspects of knowing, thus what critical aspects of causality in pricing, that could be discerned through the use of different visual representations of pricing.

Finally, I would like to make a remark on generalisability within a qualitative research approach. Within a qualitative research tradition, one does not strive for generalisation in a deterministic manner (Carlgren, 2012). There is thus a potential generalisation, but not a mechanical. Larsson (2009) suggests that generalisation should be seen as “a working hypothesis, not a conclusion” (p. 37) and “a pragmatic matter, where perfection has no place” (p. 36). Generalisability in relation to the studies presented in this thesis should be considered as formulated by Larsson (2009) – a working hypothesis rather than an assured conclusion or a deterministic connection. It is worth noting that my ambition in investigating what learning is facilitated through the use of different visual representations of the same subject content is not to assure a deterministic connection between the use of a certain visual representation and certain aspects of learning. Rather, my ambition is to unfold possible critical aspects, in terms of specification rather than generalisation, that seem to be made visible to the students through the use of different visual representations.

Knowledge interest

Habermas (1987) presents three knowledge interests: technical, practical and emancipatory. The different knowledge interests make possible different kinds of knowledge claims in research, as the aims of the research are different depending on what kind of knowledge one is focusing. The knowledge interest in this thesis is mainly practical and emancipatory: practical in that the focus is on understanding what learning is facilitated through the use of different visual representations and emancipatory in that the traditional way of using visual representations in teaching economics is partly questioned and problematised. With a practical knowledge interest, focus is on interpreting and understanding the phenomenon researched, rather than ascribing the phenomenon laws and predictions. The aim is accordingly more practical, based on a hermeneutic approach and with a focus to reach a deeper understanding of the
phenomenon researched (Newton & Burgess, 2008). With an emancipatory knowledge interest, based on a critical approach, one aims to find possible laws in order to reveal and counteract them. By unfolding and thereby criticising the way things seem to be, things can change (Newton & Burgess, 2008; White, 1999). The design presented in Paper II may seem technical, as it investigates learning through different visual representations of the same subject content, and as a technical knowledge interest aims at finding laws and explanations (White, 1999). However, and important to note, the aim with this thesis is not to conclude, generalise and predict what will happen to student learning when one or the other visual representation is being used in teaching economics. Rather, focus is on understanding how students’ conceptions of causality in pricing develop in relation to two different visual representations of the concept and what aspects of price are made possible for students to discern through these visual representations. It is accordingly not the laws and predictions that are in focus, but a deeper understanding of teaching and learning in relation to the representations used. The main question is not ‘what works’, but ‘how, when and why’ it works, as well as specifying what ‘it’ is (Cobb et al., 2003).

Ethical aspects

Conducting research in a school setting involves many ethical considerations that need to be handled carefully and with delicacy. This research has been conducted in accord with APA standards as well as the ethical guidelines from the Swedish Research Council. Different ethical considerations concerning this research have been discussed with colleagues and co-researchers to ensure well-reasoned decisions.

All participants, teachers as well as students, were informed about the aim of the research, how it would be conducted, and how data should be handled and used. This information was given both orally and in writing. The school administration at the two schools were also informed about the research and they gave their consent. It was emphasised that participation in the study was voluntarily and it could be cancelled anytime. All participants were also informed about and gave their consent to the research data being used only for research and educational purposes (such as teacher education, seminars, etc.). All participating students gave a written consent to participating. Three students, from three different classes, chose not to participate. As the lessons included in the study were part of ordinary teaching, all students still attended the lessons, but those who chose not to participate did not answer the pre- and post-test questions and did not engage in the small group discussions. In order to make it easier for students to feel free not to participate, the information about the study and the participation was given by me as an outsider, not by their teacher on which they depend when it comes to grading in the courses involved.
All data, students’ written answers as well as filmed lessons and filmed group discussions, have been locked in safe storage in accordance with official regulations. The material has been collected and used in a way that assures confidentiality and anonymity for all persons involved. Students’ written answers were coded with numbers to avoid that the names were revealed and that students could be identified by a third party. In the transcription process, students and teachers were allocated numbers for identification. Lessons were filmed from the rear part of the classroom, facing the teacher and the whiteboard, in order to avoid filming students’ faces. Cameras were also placed so that students who wanted could choose a place behind the camera. Group discussions were filmed focusing only on the sheet of paper with the visual representation and the discussion questions spelled out. This facilitated for me to hear the discussions and see how the students used the illustration, in terms of pointing, without students’ faces being revealed.

Four additional aspects of ethical considerations are worth mentioning in this context. First, and important to note, the object of research in this thesis is the relationship between learning and the visual representation used in teaching. The object of research is thus not the teachers or the students, although they are necessary participants. My aim was not to evaluate teachers or students, but to deepen the understanding of learning about causation in pricing through the use of different visual representations. Second, the data collected during the research lessons was not used by the teachers to grade the students. This was important to let the students know, as it would have been ethically problematic to ask students to participate in something which on the one hand is said to be voluntarily, but on the other hand is included in the teacher’s grading. Third, it was important to let this study be part of the ordinary teaching in order not to take time from teaching to research, but rather combine the two. Fourth, the content in focus for the research lessons was pricing in economics teaching, which was not considered a sensitive or ethically problematic topic. Nothing sensitive was found in the written or filmed material and there was thus no risk for physical or psychological harm for participating teachers or students.
6. Overview of studies

The thesis includes three papers, apart from the two papers included in the licentiate thesis which this thesis builds on (Jägerskog, 2015). The three papers will be presented in short below.

Paper I: Students’ understanding of causation in pricing: a phenomenographic analysis


Aim

The aim of this study was to extend previous research on conceptions of price by highlighting variation in students’ understanding of causality. It also aimed to offer a new way of using ‘dimensions of variation’ in phenomenographic research to analyse the structure of conceptions of complex phenomena. More specifically, the study investigated (i) variation in how students understand causation in their conceptions of pricing, (ii) how dimensions of variation in conceptions of pricing are related to each other and (iii) how the scope of a question affects the dimensions of variation in conceptions of price that come into view.

Background

Most earlier studies investigating students’ conceptions of price (Dahlgen, 1984; Meyer & Shanahan, 2002; Pang & Marton, 2005) focus on one dimension of variation at the time, such as (i) quantity supplied and demanded, that is how quantity affects price (Pang & Marton, 2005); (ii) the slope of the demand/supply curves, that is how price affects quantity supplied and demanded

\(^1\) Jägerskog has been designing the study, collecting and analysing data, as well as writing the manuscript. Davies has contributed in designing the study, interpreting data as well as writing the manuscript. Lundholm has contributed in the planning process of the study as well as in revising the manuscript.
(Pang & Marton, 2003); or (iii) variation between a producer or a market focus, that is how the locus of decision-making affects quantity supplied (Davies, 2011, 2019; Durden, 2018) (see Table 4, dimensions 1-4). Previous literature has not considered the relationship between learners’ progress in each of these dimensions and that is one of the issues addressed in this paper.

Also, previous phenomenographic research on students’ conceptions of price has not identified and investigated causation as a distinct dimension of variation in conceptions of price. Causation is central in conceptions of economics phenomena. Everyday reasoning typically uses unidirectional conceptions of causation, although conceptions suggested by the discipline of economics emphasise bidirectional views of causation within economic systems (e.g., Leijonhufvud, 1969; Lundholm, 2018; Lundholm & Davies, 2013). Students’ conceptions of causality in pricing was especially focused upon in this study.

The paper’s review of previous studies also identified ways in which the form of questions/tasks posed to students has influenced which dimensions of conceptions of price have been exposed to scrutiny. Questions such as ‘why has the price changed’ (e.g., Pang & Marton, 2005) have exposed the dimension of effect of supply and/or demand on price. Questions such as ‘how much will price change if supply is changed by this particular amount’ (e.g., Pang & Marton, 2003) have exposed the dimension of variation in the relationship between demand and price (shape of the demand curve or the effect of change in price on demand). Durden’s (2018) study showed that posing a problem explicitly in the context of a single business discouraged answers that articulated a market conception, whilst problems posed explicitly in terms of a market opened up the space for students to answer either through a ‘business conception’ or a ‘market conception’. In this study we purposefully chose to pose questions that opened up for students to think about price in terms of several dimensions of variation. The questions used in this study asked students to consider the effect of a change in one market on price and quantity in another market.

Method

The study was carried out using a phenomenographic and variation theory perspective and method (Marton, 2015) that views learning as developing of a more complex and qualified way of understanding or experiencing a certain phenomenon, in this case causal relationships in pricing. Phenomenography aims to identify qualitatively distinct conceptions of a phenomenon. These conceptions are ordered in an ‘outcome space’ from the least to the most powerful conception (Åkerlind, 2005). The study used data from 94 upper secondary students who were asked to provide written answers to two problems before and after a short programme of teaching. This yielded a total of 328 open responses which were analysed phenomenographically (Marton, 2015; Åkerlind, 2005). The analysis focused on identifying qualitatively different
ways of seeing/experiencing the causal relationships in pricing. Phenomeno-
graphic analysis accepts that it is possible for one student to express more than
one way of understanding the relationships in pricing, placing different parts
of their response in different categories of descriptions/conceptions (Marton,
2015). A subsample of the students’ written responses (10%) were inde-
pendently analysed by two researchers who then compared and discussed their
interpretations of the data. A reliability analysis of researchers’ application of
the agreed categories was high (r = .94).

Results
The study presented four qualitatively distinct ways of understanding causa-
tion in pricing: (i) a direct relationship between supply and demand with no
reference to price; (ii) a unidirectional causal relationship between price and
demand/supply; (iii) bidirectional causal relationships between either price
and demand or between price and supply; (iv) complex relationships, where
price, demand and supply are interrelated (see Figure 8). Three critical aspects
of the causal relationships in price were identified, necessary for students to
discern in order to develop a more qualified conception of pricing. First, un-
derstanding price as a coordinating mechanism seemed to be critical in order
to move beyond Conception 1. Second, moving from Conception 2 to Con-
ception 3 required awareness of feedback effects, thus discerning mutual in-
fluence as a key characteristic. Third, moving beyond Conception 3 required
awareness of the interrelations between supply, price and demand.

Figure 8. A hierarchical outcome space of the causal relationships in pricing,
highlighting critical aspects of the phenomenon.

These results extended earlier research on conceptions of supply (Pang &
Marton, 2003), as we frequently observed a conception of price having to do
with the slope of the supply curve that has not been reported in previous research (see Table 4, dimension 3, row(ii)). Many students expressed a mistaken understanding of producers having to increase prices if they sold less (in order to cover costs), suggesting a downward sloping supply curve, rather than an upward sloping curve (suggesting that price will increase if demand increases).

The results also revealed new insights into how different dimensions of variation in conceptions of pricing are related to each other (see Table 4). The analysis suggested that an understanding of the locus of decision-making concerning price – producers or markets – was crucial for students’ understanding of price. First, we identified a strong association between a producer perspective on price (dimension 4, category (i)) and treating the supply curve as downward sloping (dimension 3, category (ii)). Utterances which suggested that suppliers would raise the price when they sold less were always framed by an individual producer perspective. Utterances that suggested an upward sloping supply curve (dimension 3, category (iii)), almost invariably were framed by a market perspective (dimension, 4 category (ii)). Second, there was an association between the stated locus of price decision making and the suggested causal relationships in pricing. Utterances that expressed a producer perspective on pricing (dimension 4, category (i)) typically suggested a one-directional causation (dimension 5, category (ii)). However, utterances that suggested a market perspective usually expressed a more complex causal relationship (dimension 5, categories (iii) and (iv)). Shifting from an individual producer perspective to a market perspective appeared to be critical in developing a more complex understanding in dimensions 3 and 5. Or the other way around, a more complex understanding of the causal relationships in pricing prompted a market perspective on pricing.

Results also suggested that the way a question or a problem is formulated when posed to students will affect the dimensions of variation in conceptions that are exposed. We found that the questions used in the study – with the purpose of opening up for a more complex way of understanding price – resulted in more dimensions of variation being expressed in students’ answers. This suggests that the formulation of a question/problem posed to students needs to be given a lot of attention, as the way it is posed seems to substantially affect what understanding of a phenomenon or concept is being expressed by the students. This conclusion is highly relevant for research as well as teaching.
Table 4. Dimensions of variation in conceptions of price identified in previous research and in the present study (in italics).

<table>
<thead>
<tr>
<th>Dimension</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tr>
<td>Quantity supplied (Q&lt;sub&gt;s&lt;/sub&gt;) and demanded (Q&lt;sub&gt;d&lt;/sub&gt;) (Pang &amp; Marton, 2005)</td>
<td>Slope of demand curve (Pang &amp; Marton, 2003)</td>
<td>Slope of supply curve</td>
<td>Producer or market focus (Davies, 2011, 2019 &amp; Durden, 2018)</td>
<td>The causal relationships in pricing</td>
<td></td>
</tr>
<tr>
<td>Causal focus</td>
<td>Q affects Price (P)</td>
<td>P affects Q&lt;sub&gt;d&lt;/sub&gt;</td>
<td>P affects Q&lt;sub&gt;s&lt;/sub&gt;</td>
<td>Locus of decision-making affects Q&lt;sub&gt;s&lt;/sub&gt;</td>
<td>The direction of causation</td>
</tr>
<tr>
<td>Categories within dimension</td>
<td>(i) Quantity not mentioned: price reflects quality of product</td>
<td>(i) No recognition of effect of price on Q&lt;sub&gt;d&lt;/sub&gt;</td>
<td>(i) No recognition of effect of price on Q&lt;sub&gt;s&lt;/sub&gt;</td>
<td>(i) Prices assumed to be set by individual producers</td>
<td>(i) Q&lt;sub&gt;d&lt;/sub&gt; affects Q&lt;sub&gt;s&lt;/sub&gt; (with P not involved)</td>
</tr>
<tr>
<td>(ii) Change in Q&lt;sub&gt;s&lt;/sub&gt; affects P</td>
<td>(ii) Negative effect of price on Q&lt;sub&gt;d&lt;/sub&gt;</td>
<td>(ii) Negative effect of price on Q&lt;sub&gt;s&lt;/sub&gt; (implied)</td>
<td>(ii) Market forces determine prices</td>
<td>(ii) Q&lt;sub&gt;d&lt;/sub&gt;/Q&lt;sub&gt;s&lt;/sub&gt; affects P or P affects Q&lt;sub&gt;d&lt;/sub&gt;/Q&lt;sub&gt;s&lt;/sub&gt;</td>
<td></td>
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<td>(iii) Change in Q&lt;sub&gt;d&lt;/sub&gt; affects P</td>
<td>(iii) Recognition that the extent to which price affects Q&lt;sub&gt;d&lt;/sub&gt; may vary.</td>
<td>(iii) Positive effect of price on Q&lt;sub&gt;s&lt;/sub&gt;</td>
<td>(iii) Competition affects scope that providers have to vary prices in relation to market norm</td>
<td>(iii) Q&lt;sub&gt;d&lt;/sub&gt;/Q&lt;sub&gt;s&lt;/sub&gt; and P mutually affect each other</td>
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<tr>
<td>(iv) Changes in Q&lt;sub&gt;s&lt;/sub&gt; and Q&lt;sub&gt;d&lt;/sub&gt; affect P</td>
<td>(iv) Recognition that the extent to which price affects Q&lt;sub&gt;s&lt;/sub&gt; may vary</td>
<td></td>
<td>(iv) Q&lt;sub&gt;d&lt;/sub&gt;, Q&lt;sub&gt;s&lt;/sub&gt; and P interrelatedly affect each other</td>
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<tr>
<td>(v) Differences between changes in Q&lt;sub&gt;s&lt;/sub&gt; and Q&lt;sub&gt;d&lt;/sub&gt; affect P</td>
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Conclusions
This study has implications for practice as well as for theory. Concerning the former, we suggest that it is highly relevant to consider how a question/problem is posed to the students, as this considerably affects what understanding of the phenomenon that come into view in their answers. Also, helping students to develop a complex understanding of the causal relationships involved in pricing, as well as an understanding of price as dependent on the market rather than an individual producer, seems to be central in teaching price to upper secondary students. Concerning the latter, we suggest that in order to understand the structure of a conception such as price, there is much to gain from a multi-dimensional analysis where several dimensions of variation of conceptions are understood in relation to each other.

Paper II: Using visual representations to enhance students’ understanding of causal relationships in price

Aim
The aim of this study was to investigate how the design of a visual representation illustrating price affects students’ understanding of the concept. More specifically I was interested in investigating (i) how students’ conceptions of causality in price develop in relation to two different visual representations (a supply/demand graph and a causal loop diagram) and (ii) what aspects of causal relationships in price are made possible for students to discern through these different representations.

Background
Previous research has suggested that it is challenging for students to grasp the deeper structures of dynamic processes (Reingewertz, 2013). One way of helping students to develop an understanding of dynamic processes and relations is through visual representations (Carney & Levin, 2002; Wheat, 2007a), such as graphs and diagrams. Economics teaching frequently uses graphs to help students understand complex relationships (Cohn et al., 2004; Reimann, 2004; Wheat, 2007a). This presumes that graphs facilitate learning about pricing by illustrating and simplifying complex processes and relations (Wheat, 2007b). However, research has identified challenges with the use of graphs in the learning situation and has questioned whether students’ learning is helped or hindered by the use of graphs (see, for instance, Cohn et al., 2001, 2004; Davies, 2012; Davies & Mangan, 2013; Estrada, 2013; Reingewertz, 2013).
A critical problem with supply and demand graphs is that they portray dynamic relationships in a static manner and thus do not easily draw attention to the dynamics of causation (Colander, 1991; Lundholm, 2018). Wheat (2007a, 2007b) proposed that this problem could be addressed by using a causal loop diagram from system dynamics, as system dynamics draw attention to the dynamics of causation. His studies provide evidence that the causal loop diagram is more effective than the graph in improving students’ understanding of price. However, he did not use the extensive phenomenographic evidence of conceptions of price in defining this improvement. Using a phenomenographic analysis makes it possible to examine how the type of diagram used influences changes in understanding, that is, in what way students’ conceptions of price develop when a causal loop diagram or graphs are being used in teaching.

This study focuses on the conceptions of causation in pricing, which were identified by Jägerskog and colleagues (Jägerskog, Davies & Lundholm, 2019). Following the conventions of phenomenography, Jägerskog and colleagues (2019) identified four qualitatively different conceptions of causation in pricing, presented in Figure 9. In the same study, Jägerskog and colleagues also identified that students tend to take either a producer or a market perspective on the relationship between price and demand, as illustrated in category 2a and 2b in Figure 9. The analysis also identified four (critical) aspects of causality in price, necessary for students to discern in order to develop more qualified conceptions of causality in price. This intervention study uses these conceptions, and the ‘critical aspects’ identified by Jägerskog and colleagues (2019) to analyse students’ developed conceptions of price as a result of a three-lesson intervention.

| Category 4. Complex relationships, where supply, price and demand are dynamically interrelated |
| Category 3. Bidirectional relationships between price & demand and/or price & supply |
| Category 2b. A unidirectional relationship between price and demand/supply: Market perspective |
| Category 2a. A unidirectional relationship between price and demand/supply: Producer perspective |
| Category 1. A direct relationship between supply & demand with no reference to price |

Critical aspect 4: The interrelation between supply, price and demand
Critical aspect 3: Mutual influence as a key characteristic of the relationships
Critical aspect 2: Price as dependent on the market, not merely a producer
Critical aspect 1: Price as a coordinating mechanism

Figure 9. Phenomenographic ‘outcome space’ of students’ conceptions of the causal relationships in pricing and associated ‘critical aspects’.
Theory
Several scholars suggest that different visual representations of the same content may communicate different aspects of the content, which facilitate different conceptions (Danielsson & Selander, 2014; Kress, 2010; Kress & Van Leeuwen, 2006). It is thus argued that how a visual representation is composed is important for which aspects of the phenomenon/knowing are given primacy and thereby are made possible for students to discern (Airey & Linder, 2009; Danielsson & Selander, 2014; McDermott et al., 1990). The idea that different representations have different potentials for communication and providing access to disciplinary knowledge has been described by some as ‘affordances’ (Gibson, 1979), or ‘disciplinary affordances’ of a visual representation (Fredlund et al., 2012), suggesting that different representations of the same phenomenon may “provide access to different disciplinary-relevant aspects” (Fredlund et al., 2012, p. 658).

Empirical research, as well as theoretical discussions, concerning learning through visual representations has been given some focus in the field of science teaching and learning (see, for instance, Fredlund et al., 2012, 2015a, 2015b; Ingerman et al., 2009). For example, it has been suggested that all representations are partial in terms of (i) all representations only being able to illustrate parts of a phenomenon, and (ii) in terms of often being ‘disciplinary rationalised’, resulting in certain aspects being implicitly, rather than explicitly, illustrated (Fredlund, et al., 2014). This rationalisation could be considered very constructive for communicating within the discipline and between experts. However, for students who cannot easily discern the important aspects that lie beyond what is explicitly visualised in the representation, this rationalization may cause problems in the learning situation (Fredlund et al., 2014).

Following the reasoning above, the supply/demand graph and the causal loop diagram, which illustrate the causal relationships in pricing in different ways, may highlight different aspects of the relationships and thereby affect what understanding of the concept that students develop.

This study uses phenomenography and variation theory to define learning, identify critical aspects and analyse data. Learning is understood as developing a more complex way of understanding or experiencing a specific subject content (Marton & Booth, 1997).

Method
An intervention consisting of three introductory lessons on pricing was conducted with four upper secondary classes (n=94), of which two had lessons based on traditional supply/demand graphs and two on a causal loop diagram (Wheat, 2007b). Students’ conceptions of the relationships between supply, price and demand, as expressed in their written answers to two open response questions before and after the intervention, were analysed in terms of change.
in understanding of the subject content between the pre- and post-test and in light of what visual representation the lessons were based on.

The results were analysed using both qualitative and quantitative methods. As for the quantitative analysis, the number of answers belonging to each category of conception in the phenomenographic outcome space (Figure 9) was summed, with results from the pre- and post-tests being summed separately for the graph-based and the causal loop diagram-based groups, respectively. Two-tailed t-tests with 95% confidence intervals, reported through p-values and Cohen’s d (effect size), were used to compare the (i) pre-test means, (ii) post-test means and (iii) change between post-test to pre-test means for the two groups (causal loop diagram and graph). As for the qualitative analysis, differences between students’ developed conceptions of causation in price in the graph group and the causal loop diagram group (as identified in the quantitative analysis) were related to the critical aspects (CA) identified in the phenomenographic outcome space (Figure 9):

1. Price as a coordinating mechanism in the relationship
2. Price as dependent on the market rather than merely the producer
3. Mutual influence as a key characteristic of the relationships
4. The interrelation between supply, price and demand

The analysis focused on what critical aspects of causal relationships in price (1-4 above) the different visual representations seemed to make possible for the students to discern.

Results

The results show that the intervention based on a causal loop diagram facilitated more qualified conceptions of causal relationships in pricing than the intervention using graphs (see Figures 10 and 11). This can be seen in the statistically significant differences between the two groups in terms of better results on the post-test for the causal loop diagram group ($M = 3.53, SD = 0.97$) than the graph group ($M = 2.56, SD = .55, p < 0.001, d = 1.23$). A majority of students in the loop diagram group expressed a more qualified understanding of the causal relationships in pricing in their post-test answers, compared to pre-test answers. In the graph group, approximately half of the students expressed a more developed understanding in the post-test answers compared to the pre-test answers, yet for half of the students in the graph intervention the reversed pattern was demonstrated: a less qualified understanding was expressed after the intervention than before.
Three of the four critical aspects identified in the phenomenographic analysis (Figure 9) were easier for students to discern when the teaching was based on a causal loop diagram than on graphs, whereas one aspect was discerned through both representations. The critical aspect discerned by students through both visual representations was price as dependent on the market rather than merely the producer (CA 2). For both groups there was a decrease in the amount of answers expressing a producer perspective after the intervention as compared to before. This suggests that both the graph and the causal loop diagram facilitated an understanding of price being part of a larger structure - a market. The remaining three critical aspects of relationships in price were clearly easier for students to discern when the teaching was based on a
causal loop diagram than on graphs. More students in the causal loop diagram group than in the graph group discerned CA 1, identifying *price as a coordinating mechanism in the relationship* (thus moved from Category 1 to 2a). This is not very surprising, as price in the causal loop diagram is placed at the centre of the illustration, connected to supply and demand. In contrast, although theoretically placed at the centre, where the supply and demand curve meet, price is visually spelled out in the upper left corner in the graph diagram. Similarly, more students in the causal loop diagram group than in the graph group discerned CA 3 and CA4 (thus moving from Category 2b to 3 and from 3 to 4). With arrows explicitly visualising *mutual influence* between supply/demand and price (CA3), as well as *interrelations between supply, price and demand* (CA4), the causal loop diagram seemed to more easily facilitate for students to discern these critical aspects. In the graph, the bidirectionality and interrelations are implicitly expressed, and students need to understand the underlying structure of the graph in order to understand it, which could be difficult for novice learners in economics.

Conclusions

The results suggest that the compositional structure of the visual representation used to illustrate causality in pricing fundamentally matters for what understanding is made possible for students to develop. This has implications for teaching economics and designing course materials on price, as it questions the use of graphs as the most efficient way of introducing price and explaining the causality involved. This study extends earlier research in terms of identifying *why*, or *in what way*, supply/demand graphs can cause problems in a learning situation, rather than merely *that* they do: for novice learners in economics, some critical aspects that seem necessary to discern in order to develop a more qualified understanding of causality in price are not necessarily explicitly made visible through the graph. This result could be understood in the light of Fredlund’s discussion of ‘disciplinary rationalised’ representations (Fredlund et al., 2014). The supply/demand graph may be an example of a visual representation being ‘disciplinary rationalised’, with several important aspects being implicit in the representation. In that sense the supply/demand graph may be very constructive for communicating within the discipline and among experts, but not for communicating the foundations of causality in pricing to novice learners in the field.

The strong tradition of graphical and algebraic models that have come to serve as an intellectual framework in economy (Kennedy, 2000) does not always seem to be fruitful in the learning situation and needs to be problematised. We might thus need to re-think how complex processes and relations could be visualised in a way that enables students to develop complex understandings of the phenomenon in focus.
This study also indicates the importance of reflecting on how visual representations facilitate conceptual understanding. The results support conclusions drawn by other scholars (see, for instance, Danielsson & Selander, 2014; Kress, 2010; Kress & Van Leeuwen, 2006) that the composition of a visual representation can have a significant influence on how the content is understood. It is thus important to pay attention to what aspects of a phenomenon are communicated, placed in the foreground versus background and made possible to discern, as different aspects of the content may be possible to discern through different visual representations.

This study also identifies a useful synergy between phenomenography and variation theory and research on visual representations, as the notion and use of ‘critical aspects’ can further deepen the understanding of what learning is facilitated through different visual representations of a phenomenon. Critical aspects can be a useful tool both for investigating what learning is facilitated through certain visual representations and in creating visual representations aiming at developing students’ understanding of a certain concept or phenomenon.

Paper III: The affordance of visual tools – the potential of visual representations of pricing facilitating an epistemic practice in economics teaching


Aim
The aim of this study was to investigate what actions two different visual representations of pricing (a supply/demand graph and a causal loop diagram), as tools, afford and what practices are constituted in a lesson series introducing pricing. Focus was on the relationship between teaching-learning practices established in the classroom and the visual representation as a tool, used in teaching. More specifically I wanted to investigate what communicative actions two different visual representations of pricing (a supply/demand graph and a causal loop diagram) afford in a lesson series introducing pricing and what teaching-learning practices thus are established (during an introductory lesson and in small group discussions).

Background
Earlier research has shown that the composition of a visual representation can have a significant influence on how the content is understood (Danielsson & Selander, 2014; Kress & Van Leeuwen, 2001; Wheat, 2007b). It has also been
suggested that different representations have different potentials for providing access to disciplinary knowledge, identified as ‘affordances’ (Gibson, 1979; Gibson & Pick, 2000). Similarly, from a practice theory perspective, visual representations have been suggested to have the potential to afford different actions (Wertsch, 1998).

In economics teaching, supply/demand graphs are frequently used as a visual tool to help students understand the complex relationships involved in pricing (Cohn et al., 2004; Reimann, 2004; Wheat, 2007a). However, previous research has shown that students often face problems when learning about pricing through such graphs (see, for instance, Cohn et al., 2001, 2004; Davies, 2012; Davies & Mangan, 2013; Estrada, 2013; Reingewertz, 2013). In four experiments, Wheat (2007b) addressed this issue by investigating how an alternative visual representation of pricing, a causal loop diagram from system dynamics, could more efficiently help students understand the dynamics in pricing. Results showed that students preferred the causal loop diagram to the static graph and that the performance, in terms of scoring on a multiple-choice test, was better when the causal loop diagram had been used rather than the static graph. An explanation to this result could be that a causal loop diagram more easily than the supply/demand graph captures the dynamics of the causal relationships in pricing.

Jägerskog (2020) extended Wheat’s (2007b) research by investigating what understanding of the causal relationships in pricing was made possible for students to develop through the use of the two different representations (the supply/demand graph and the causal loop diagram). Results showed that the causal loop diagram to a greater extent than the supply/demand graph facilitated for the students to discern critical aspects of the causal relationships in pricing and thus facilitated more qualified conceptions of pricing than did supply/demand graphs.

Each of these studies focuses on how the use of a certain visual representation is related to students’ conceptions of price. However, they do not tell us how the choice of visual representation in teaching may relate to teaching-learning practices established in the classroom. This aspect is important to take into consideration when trying to understand the relationship between visual representations and learning, as the teaching-learning practice that students are invited to participate in is related to what learning may be made available (Chaiklin & Lave, 1993; Lave & Wenger, 1991; Eriksson & Lindberg, 2016). This study takes a practice theory perspective to investigate this matter further.

Theory
A central idea in a practice theory perspective is that learning, understanding and meaning are defined relative to actional contexts, rather than self-contained structures (Lave & Wenger, 1991). This implies that knowledge is constituted in, and actualised through, people’s actions (Knorr Cetina, 2007; Radford, 2015) and that learning happens through social practices (Lave, 1993).
‘The practice’ could thus be seen as a theoretical entity (Lave, 1993) and is a good place to investigate phenomena such as knowledge and learning (Schatzki, 2001). A practice can be defined by identifying what the actors want to accomplish, thus what is going on and why, and are realised through goal-oriented actions (Eriksson, et al., 2004; Eriksson & Lindberg, 2016).

Four central ideas within a practice theory perspective are of special interest for the analysis of this paper. First, an action is driven by its goal (Wertsch, 1998, see also Leont’ev, 1978). This implies that actions are intentional and that any action can be characterised by identifying its goal. Second, classroom actions, including both teachers and students, is the unit of analysis, as participating in a practice is what makes learning possible (Lave & Wenger, 1991; Radford, 2015, 2018). In that sense, a practice is identified through an analysis of the participants’ actions, such as communicative actions, and the goals driving them. Third, the tools that are used and developed in the practice mediate the actions and contribute to forming the practice (Schatzki, 2001; Wertsch, 1998). Tools, such as artefacts and models, are suggested to have a mediating function (Wertsch, 1998) in that different tools may facilitate, or afford, different actions and thus affect what is made possible for students to learn. Fourth, participating in a certain practice facilitates the development of certain abilities and ways of knowing (Lave & Wenger, 1991). This implies that the kind of practices students are invited to participate in is closely related to what abilities can be developed (Carlsgren, 2011; Radford, 2018).

The term teaching-learning practice refers to the practices established in the classroom during a lesson. Knorr Cetina (2001) suggests that practices can be either epistemic, or habitual. In an epistemic practice, learning and ‘knowledge production’, thus developing and transforming knowledge required in a specific situation, are the main objects. In contrast, habitual practices are characterised by routine and tradition. (Knorr Cetina, 2001). Knowledge is not developed and transformed in habitual practices as is the case in epistemic practices. Ewenstein and Whyte (2009) suggest that visual representations can play an important role, not just by embedding and inscribing knowledge, but by generating questions and encouraging “wanting and unfolding in uncharted directions” (Ewenstein & Whyte, 2009, p. 22), thus encouraging an epistemic practice. On the other hand, they suggest, visual representations as tools in a practice can also be treated technically, thus as unproblematic, ready-to-hand instruments, where the knowledge represented is treated as given. Visual representations as tools in a practice can thus potentially, but not necessarily, facilitate the establishing of an epistemic practice.

Method
In a series of three lessons, four upper secondary classes were introduced to economics and pricing. Two of the classes had lessons based on traditional supply/demand graphs and two on a causal loop diagram (Wheat, 2007b). The
lessons included teacher lecturing as well as small group discussions (in all 21 groups).

Transcriptions from the introductory lecture were analysed qualitatively in order to identify teachers’ and students’ communicative actions during this lesson and goals driving them (see Figure 12 below). Teachers’ and students’ communicative actions were also related to each other in order to investigate if some teacher communicative actions encouraged certain student communicative actions. Teaching-learning practices established were identified. Descriptive statistics were used to illustrate the occurrence of different communicative actions in the graph-based and causal loop diagram-based classrooms respectively and how teachers’ and students’ communicative actions were related to each other (see Tables 5 and 6).

Also, transcriptions from small group discussions were analysed in order to identify students’ communicative actions. Students’ conceptions of the role of the visual tool used were also identified and related to their communicative actions, in order to investigate if there was a pattern in students’ conception of the role of the visual representation and the actions that emerged. Goals of the different actions were identified, as were teaching-learning practices established.

**Figure 12. Schematic description of qualitative analysis of introduction lecture and small groups discussion.**
Results
The analysis revealed that there was a relation between the visual representation used in teaching and the teaching-learning practice established in the classroom, thus what communicative actions the different visual tools afforded. The pattern was similar for both lecture and small group discussions: a causal loop diagram afforded more qualified communicative actions and a more qualified conceptions of the causal relationships in pricing than graphs.

In the introductory lecture, two different teaching-learning practices were established: a *describe logics – explain cause and effect* practice in the graph-based lecture and an *explain cause and effect – elaborate on complex relationships practice* in the diagram-based lecture (see Tables 5 and 6 below). In graph-based lectures, students’ communicative actions were mainly characterised by asking for clarification of the illustration (A in Table 5) and/or of causation (B in Table 5) and teachers’ communicative actions were mainly characterised by describing logics ((i) in Table 5) and/or explain cause and effect ((ii) in Table 5). In the causal loop diagram-based lectures, students’ communicative actions were mainly characterised by commenting on the character of causation (C in Table 6), problematizing (D in Table 6), or reflecting on the relationships involved (E in Table 6) and teachers’ communicative actions were mainly characterised by explaining cause and effect ((ii) in Table 6) and/or elaborating on complex relations ((iii) in Table 6).

Table 5. A *describe logics – explain cause and effect* practice established in the graph-based lecture: distribution of students’ communicative actions in relation to teacher’s communicative actions.

<table>
<thead>
<tr>
<th>Students’ communicative actions</th>
<th>(i) Describe logics</th>
<th>(ii) Explain cause &amp; effect</th>
<th>(iii) Elaborate on complex rel.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Clarification of the illustration</td>
<td>13 (65%)</td>
<td>2 (7,1%)</td>
<td>1 (25%)</td>
<td>16 (30,8%)</td>
</tr>
<tr>
<td>B. Clarification of a causation</td>
<td>3 (15%)</td>
<td>18 (64,3%)</td>
<td>0 (0%)</td>
<td>21 (40,4%)</td>
</tr>
<tr>
<td>C. Make a statement about/comment on the character of a causation</td>
<td>4 (20%)</td>
<td>7 (25%)</td>
<td>1 (25%)</td>
<td>12 (23,1%)</td>
</tr>
<tr>
<td>D. Problematise/exemplify with other good or condition</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>E. Reflect about relationships between several variables in price</td>
<td>0 (0%)</td>
<td>1 (3,6%)</td>
<td>2 (50%)</td>
<td>3 (5,7%)</td>
</tr>
<tr>
<td>Total</td>
<td>20 (38,5%)</td>
<td>28 (53,8%)</td>
<td>4 (7,7%)</td>
<td>52 (100%)</td>
</tr>
</tbody>
</table>
Table 6. An explain cause and effect – elaborate on complex relationships practice established in the causal loop diagram-based lecture: distribution of students’ communicative actions in relation to teacher’s communicative actions.

<table>
<thead>
<tr>
<th>Students’ communicative actions</th>
<th>(i) Describe logics</th>
<th>(ii) Explain cause &amp; effect</th>
<th>(iii) Elaborate on complex rel.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Clarification of the illustration</td>
<td>0 (0%)</td>
<td>3 (8,8%)</td>
<td>0 (0%)</td>
<td>3 (7,3%)</td>
</tr>
<tr>
<td>B. Clarification of a causation</td>
<td>0 (0%)</td>
<td>4 (11,8%)</td>
<td>1 (14,3%)</td>
<td>5 (12,2%)</td>
</tr>
<tr>
<td>C. Make a statement about/comment on the character of a causation</td>
<td>0 (0%)</td>
<td>20 (58,8%)</td>
<td>1 (14,3%)</td>
<td>21 (51,2%)</td>
</tr>
<tr>
<td>D. Problematise/exemplify with other good or condition</td>
<td>0 (0%)</td>
<td>7 (20,6%)</td>
<td>1 (14,3%)</td>
<td>8 (19,5%)</td>
</tr>
<tr>
<td>E. Reflect about relationships between several variables in price</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>4 (57,1%)</td>
<td>4 (9,8%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0 (0%)</strong></td>
<td><strong>34 (82,9%)</strong></td>
<td><strong>7 (17,1%)</strong></td>
<td><strong>41 (100%)</strong></td>
</tr>
</tbody>
</table>

In the small group discussions, two different teaching-learning practices were established: a *not understand - decode - confirm practice* in graph-based small group discussions and a *discuss pricing practice* in causal loop diagram-based small group discussions (see Tables 7 and 8 below). In graph-based small group discussions, students’ communicative actions were characterised by stating that one did not understand the illustration (A in Table 7), trying to decode the different parts of the illustration (B in Table 7) and/or suggesting/confirming misleading logics (C in Table 7). The visual representation was in those groups considered either an illogical illustration (i in Table 7), an objective for the discussion (ii in Table 7), or a means for discussing pricing (iii in Table 7). In causal loop diagram-based small group discussions, students’ communicative actions were characterised by discussing the logics of the relationships involved in pricing (D in Table 8) and the visual representation was considered a means for discussing pricing (iii in Table 8).
Table 7. *A not understand - decode - confirm practice* established in the graph-based small group discussions: distribution of students’ communicative actions in relation to their conceptions of the role of the visual representation. Results for graph-based small group discussions only.

<table>
<thead>
<tr>
<th>Conception of the role of the visual representation as...</th>
<th>Communicative actions</th>
<th>(i) Illogical illustration</th>
<th>(ii) Objective for discussion</th>
<th>(iii) Means for discussing pricing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No use of the vis. repr. in the discussions</td>
<td>A. State that one does not understand the illustration</td>
<td>B. Try to decode and understand the illustration</td>
<td>C. Suggest and confirm misleading logics</td>
</tr>
<tr>
<td>Group 1</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Group 2</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Group 3</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 4</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Group 5</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 6</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Group 7</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 8</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Group 9</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 10</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 11</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 8. A discuss pricing practice established in the causal loop diagram-based small group discussions: distribution of students’ communicative actions in relation to their conception of the role of the visual representation. Results for causal loop diagram-based small group discussions only.

<table>
<thead>
<tr>
<th>Conception of the role of the visual representation as...</th>
<th>(i) Illogical illustration</th>
<th>(ii) Objective for discussion</th>
<th>(iii) Means for discussing pricing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communicative actions</td>
<td>No use of the vis. repr. in the discussions</td>
<td>A. State that one does not understand the illustration</td>
<td>B. Try to decode and understand the illustration</td>
</tr>
<tr>
<td>Group 1</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 3</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Group 4</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Group 5</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Group 6</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Group 7</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Group 8</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Group 9</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Group 10</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Conclusions

Results suggest that the teaching-learning practices established in causal loop diagram-based classrooms to a large extent could be characterised as epistemic practices, where developing knowledge and thus learning about pricing were the main objects. In contrast, teaching-learning practices established in graph-based classrooms did not to the same extent contribute to establishing such epistemic practice. In the graph-based groups, focus was mainly given to understanding the visual representation as such and the logics behind it, rather than discussing the inner workings of the causal relationships involved in pricing. This pattern was identified in both the introduction lecture and the small group discussions. Consequently, the causal loop diagram mainly afforded discussions concerning the causal relationships in pricing, thus functioned as a means for developing an understanding of causality in price and encouraged further questions and reflections, whereas the graph rather functioned as an objective in itself, considered as a given ready-to-hand instrument that needed to be technically decoded and learnt and understood ‘in the right way’. One way of understanding this result is in light of Radford’s (2015) idea of practical activity setting an object of knowledge in motion. It appears that a causal loop diagram, to a greater extent than a supply/demand graph, set the object...
of knowledge in motion in these groups. This does not imply that the causal loop diagram per se encourages an epistemic discussion practice and the supply/demand graph a more technical. Rather, they both have the potential to do the former, but the graph seems to be more at risk to be treated technically, by teachers as well as novice learners in economics.

The visual representation as an action mediating tool, playing a central role in forming the teaching-learning practice established, and thereby the learning facilitated, become evident in this study. This implies that teachers, when choosing visual tools to include in their teaching, need to consider the visual representations as artefacts that play an active role in how the teaching and communication will evolve, and pay attention to what the visual tools afford, thus what communicative actions and teaching-learning practices are being established through the use of them. In that sense the main result of this study is not merely that a causal loop diagram seems to afford a more epistemic practice in the classroom than a supply/demand graph, but that the choice of visual tools used in teaching will affect the practice established and thus the knowledge made available for students to experience.
7. Summary and discussion of results

In this chapter I will first briefly summarise the results presented through the three papers. I will then discuss those results in terms of the two challenges raised in the introduction chapter and formulated in the overall research questions of this thesis: (i) visual representations as simplified illustrations of complexities and (ii) different goals of a visual representation - when used in the discipline and when used in social science teaching.

Summary of results

How the three papers together form a coherent unity

The three papers included in this thesis each contribute with interesting and important results and conclusions in relation to economics teaching in particular and social science education in general. However, they also together form a coherent unity, as the three papers build on each other. In Paper I, using phenomenography and variation theory, causality was identified as a central dimension of variation in understanding pricing. Different conceptions of causality in pricing were identified in students’ written answers and critical aspects of causal relationships in pricing were identified. In Paper II, two different visual representations of pricing were used in teaching in order to facilitate for students to discern the critical aspects identified in Paper I. Results revealed that an intervention based on a causal loop diagram was much more successful than supply and demand graphs in helping students to discern the critical aspects identified in Paper I. The causal loop diagram thus facilitated a development of more qualified conceptions of causality in pricing than did supply/demand graphs. Paper II also indicated why the two different visual representations of pricing facilitated very different conceptions of pricing and why the supply/demand graph caused problems in the learning situation. Paper II concluded that different visual representations of a subject content may facilitate discernment of different aspects of a phenomenon. In that sense, compositional structure of a visual representation plays a vital role for how the content visualised is understood by students and which aspects of the phenomenon are more easily discerned and which are not. Although Paper II opened up for conclusions concerning the importance of the compositional structure
of a visual representation, aspects such as the context, how the visual representation is used by teachers and students, and what the visual representation affords in the practice, were not focused upon in this paper. In order to further deepen and broaden the understanding of why the compositional structure of the two visual representations of pricing resulted in very different conceptions among the students (as described in Paper II), a practice theory perspective was applied in Paper III, as a practice theory perspective takes its outset in the practice. In Paper III, this theoretical perspective enabled me to interpret the conclusions drawn in Paper II and to deepen the understanding of why the causal loop diagram seemed to facilitate more qualified conceptions of causality in pricing than the graph among novice learners. Results suggested that the causal loop diagram, to a greater extent than the graph, contributed to establishing an epistemic practice by affording discussions about the causal relationships and by encouraging further questions and reflections. The results presented in Paper III showed that a visual representation as an action-mediating tool plays a central role in forming the teaching-learning practices established in the classroom.

Extension of earlier research on students’ conceptions of price

Much previous research has focused on students’ conceptions of price (see, for instance, Dahlgren, 1984; Davies, 2011, 2019; Durden, 2018; Pang & Marton, 2003, 2005). The studies presented in this thesis confirm many of the conclusions drawn in previous research. For instance, earlier studies have identified several problems related to learning about pricing through graphs. Examples of problems identified are that dynamic and complex systems and processes are easily misunderstood when they are simplified (Cohn et al., 2001; Davies & Mangan, 2013), that graphs are difficult for students to understand (Cohn et al., 2004), that parts of the problem with understanding graphs is related to understanding key concepts (Ignell et al., 2017) and that it can be problematic for students to understand how graphs are attuned to the ‘real world’ (Davies and Mangan, 2013; Strober & Cook, 1992). Those challenges were confirmed in the studies included in this thesis. In addition, different dimensions of variation of conceptions of price identified in previous research, such as how quantity demanded/supplied is related to price (Dahlgren, 1984; Pang & Marton, 2005), how a given change in price might affect quantity demanded/supplied (Pang & Marton, 2003), and how price is a decision of an individual producer or an outcome of market forces (Davies, 2011, 2019; Durden, 2018), were also observed in the analysis of students’ conceptions of price included in this thesis (Paper I).

The three papers also extend previous research on students’ conceptions of price. First, Paper I highlights causality as a central dimension of price and identifies different student conceptions of those causal relationships. The analysis identified four critical aspects of causality in pricing, necessary for stu-
dents to discern, thus needed to be focused upon in teaching, in order for students to develop a qualified conception of causality in pricing. The four aspects needed to be discerned are: (i) price as a coordinating mechanism, (ii) price as dependent on the market, not merely the producer, (iii) mutual influence as key characteristics of the relationships and (iv) the interrelation between supply, price and demand. Second, much previous research has identified that supply/demand graphs cause problems for students in their attempt to understand pricing. This thesis extends those results by deepening the understanding of why, or in what way, supply/demand graphs can cause problems in the learning situation. The research identified some critical aspects that novice learners in economics need to discern in order to develop a more qualified conception of causal relationships in pricing are not necessarily explicitly made visible through the graph. Also, as presented in Paper III, the causal loop diagram (more than the supply/demand graph) seems to contribute to the establishing of an epistemic practice. Third, this thesis extends Wheat’s (2007b) research in two ways. Results in this thesis do not only suggest that the causal loop diagram facilitates learning of pricing, but also in what way it does. In other words, it highlights the critical aspects that the illustration seems to enable learners to discern. Also, results show that the causal loop diagram is very useful as a static visual representation and does not have to be used as a dynamic computer simulation model, as was the case in Wheat’s (2007b) study. Interestingly, this suggests that an illustration of pricing, although static and simplified, can be designed in a way that captures the dynamics involved and thereby facilitate a complex understanding of the processes and relations involved.

To sum up, the studies in this thesis investigate teaching and learning in social science with a focus on economics in upper secondary school. The research focused on causation in pricing, using supply/demand graphs and a causal loop diagram as visual representations.

Future research
Future studies might replicate this research focusing on different age groups, different subject content and different visual representations, in order to explore the full potential of the findings in the three papers presented here. Furthermore, future studies could investigate how a causal loop diagram and a supply/demand graph could be combined in teaching in order for students to both understand the causal relationships in pricing (as efficiently visualised in the causal loop diagram) and grasp the disciplinary relevant illustration (the supply/demand graph). Also, future studies could deepen the understanding of visual representations in light of phenomenography and variation theory by analysing what variation is made explicit in the visual representations used.
Challenge 1: Visual representations as simplified illustrations of complexities

Learning in social science involves developing an understanding of complex, dynamic and sometimes rather abstract concepts and phenomena. This often involves challenges for the teacher, as complex relations and processes need to be explained to the students in a comprehensible, partly simplified, way, without losing its complexity. One of the great possibilities with the use of visual representations in teaching and learning in social science is their potential to present complex phenomena in a simplified way. However, as previously mentioned, this possibility is also a major challenge with several risks involved. One of the research questions for this thesis focuses on what role the compositional structure of a visual representation of pricing plays in developing students’ conceptions of causality in pricing and for teaching-learning practices established in the classroom. This question contains the challenge presented above and the discussion below will shed light on and give some potential answers to this question.

In the following sections, I will first present and discuss risks involved when using partly simplified visual representations to illustrate complexities, based on previous research as well as conclusions drawn from the studies included in this thesis. I will then discuss three possible ways of dealing with those challenges.

Risks involved when using partly simplified visual representations to illustrate complexities

Several risks are involved when partly simplified visual representations are used in teaching to illustrate complexities. I would like to mention three of them here and relate them to the findings presented in the different papers. First, there is a risk that students focus on how to understand and manipulate the form (the representation itself), rather than on how to understand the conception or phenomena which it represents. This challenge can lead to students being able to draw a certain model without actually understanding the structures and relations. Students may spend all their time discussing how to interpret a visual representation, rather than discussing the structures, processes or relations that the visual representation tries to convey. Focus can thus be given to understanding and handling the visual model that represents a concept, rather than to understanding a concept through a visual representation. This risk has been highlighted in previous research (Cohn et al., 2001; Davies & Mangam, 2013) and this risk also became evident in the studies included in this thesis. Results presented in Paper III show that students in graph-based groups, to a greater extent than students in causal loop diagram-based groups, focused on the representation itself, rather than the phenomenon illustrated. In classroom and small group discussions using the graph there was a clear dom-
inance of trying to understand the visual representation itself, rather than pricing. A focus on understanding the representation as such often occurred at the cost of a focus on the more underlying structures. The inner workings of pricing were much more in focus when students worked with the causal loop diagram, resulting in more qualified discussions and conceptions of causation in pricing. Accordingly, the compositional structure played an important role for qualifying students’ conceptions of pricing and teaching-learning practices established in the classroom.

Second, when complex and dynamic phenomena and concepts are illustrated statically and in a simplified manner, there is a risk that students misunderstand the inner workings of a phenomenon and draw simplified or mistaken conclusions. This challenge risks resulting in students having a too simplified, or even mistaken, conception of the concept or phenomenon visualised. One of the central tasks for teachers using those representations thus becomes helping students to see ‘beyond’ the static and simplified representation, thus understanding the complexity and dynamics embedded in the visual representation. This is an aspect that I will come back to in the following section. The risk of simplified visual representations resulting in misunderstandings and simplified conclusions has been highlighted in previous research (see, for instance, Cohn et al., 2001; Colander, 1991; Davies & Mangan, 2013; Wheat, 2007a). This risk also became evident in the studies included in this thesis. In paper II, investigating students’ conceptions of causal relationships in pricing before and after an intervention, students who had teaching based on graphs developed less qualified conceptions of pricing than students having teaching based on a causal loop diagram. Results even suggested that the use of graphs in some cases was counterproductive, as some students expressed a less qualified understanding of causality in pricing after the intervention than before, which is in line with results presented by Cohn and colleagues (2001). This risk became evident also in Paper III, investigating the introduction lecture and small group discussions. More qualified reflections and conclusions were drawn in causal loop diagram-based introductory lectures and small group discussions, than in graph-based groups. More misunderstandings and clarifying questions, were expressed in graph-based introductory lectures. Also, in small group discussions, graph-based groups to a greater extent than causal loop diagram-based groups suggested and confirmed misleading logics. Accordingly, the compositional structure of visual representations illustrating causality in pricing clearly influenced both students’ conceptions of causality in pricing and teaching-learning practices established in the classroom.

Third, there is a risk that teaching uses simplified visual representations without really knowing to what extent, or in what way, this facilitates, or even hinders, a complex and qualified understanding of the content visualised. If we do not know how a visual representation encourages learning, we risk using illustrations that do not facilitate learning the way we want them or believe them to do and we risk missing out on visual representations that could facilitate learning. We also risk using visual representation in the belief that they
help students develop a qualified understanding of the content visualised, without realizing that they tend to do the opposite. As suggested by several scholars, the compositional structure of a visual representation, aspects being placed in the foreground versus background, will affect what is communicated, thus what aspects of the content visualised will be made possible for students to discern (see, for instance, Danielsson & Selander, 2014: Kress, 2010).

Three ways of dealing with the risks involved

I will now present three aspects, based on earlier research and results from the studies included in this thesis, that could be helpful when striving to deal with the three risks mentioned above. Those three aspects are (i) understanding visual representations as partial and rationalised, (ii) understanding visual representations as potential tools in the establishing of an epistemic practice and (iii) understanding visual representations as facilitating critical aspects of the phenomenon to be discerned.

Understanding visual representations as rationalised and partial

All visual representations are partial in nature. Understanding this is probably one of the keys to developing an understanding of complexities through simplified visual representations. As mentioned earlier, Fredlund and colleagues (Fredlund et al., 2014) suggest that visual representations are partial in two ways: they are limited in terms of the meaning they can convey and they are often being ‘disciplinary rationalised’ (Airey & Linder, 2009; Kress, 2003; Halliday & Martin, 2003; Fredlund et al., 2014). This latter aspect implies that visual representations to different extents have aspects or parts of the intended meaning that are implicit, thus taken for granted, and therefore not explicitly visualised in the representation. The rationalisation of visual representations is a natural consequence of the discipline trying to condense complex ideas. Rationalised representations often work well for communication within the discipline, but can be problematic for novices in the field (Fredlund et al., 2014).

The supply/demand graph, being a central disciplinary illustration of pricing, could be understood as an example of a visual representation that is ‘disciplinary rationalised’, with several important aspects being implicit in the representation. In order to understand the representation, those ‘rationalised away’ aspects need to be ‘unpacked’ or ‘de-rationalised’ (Fredlund et al., 2014). Although all representations contain implicit aspects, the causal loop diagram could be understood as having fewer aspects rationalised away, necessary to get unpacked in order for students to be able to grasp the representation and its complexity. The many rationalised-away aspects in the supply/demand graph is one possible explanation to why the graph-based lessons and discussions to such a great extent focused on understanding the representation as such, rather than the inner workings of pricing (risk 1 mentioned above).
The more rationalised-away aspects a representation conveys, the more problematic it may be for a novice learner to grasp the visual representation, and the more time and effort is needed to unpack the representation. A supply/demand graph thus seems to need more unpacking than the causal loop diagram. This became evident in the small group discussions, where many graph-based groups got stuck in the representation itself, trying to understand it, whereas discussions in causal loop diagram-based groups mainly dealt with the inner workings of pricing, using the loop diagram as a means for discussing this. Similarly, the fact that students in the graph-based group developed less qualified conception of the inner workings of pricing and drew more simplified or mistaken conclusions (risk 2 mentioned above) could be understood in light of the graph being disciplinary rationalised. If the implied aspects are not unpacked, there seems to be a major risk that students misunderstand the inner workings of the phenomenon visualised and that they draw simplified or mistaken conclusions. This seemed to be the case for many students in the graph-based groups. When dealing with the risks mentioned in the section above, it may be helpful to think about visual representations in terms of illustrations with implied aspects that need to be unpacked through teaching. In this sense, the compositional structure of a visual representation, and the way it is unpacked, or de-rationalised by the teacher, plays a crucial role for students’ conception of the content visualised.

**Understanding visual representations as potential tools in the establishing of an epistemic practice**

Visual representations can play an important role in the establishing of a practice, (Ewenstein & Whyte, 2009; Wertsch, 1998). On the one hand, visual representations as action-mediating tools have the potential to generate questions and encourage “wanting and unfolding in uncharted directions” (Ewenstein & Whyte, 2009, p. 22), thus contribute to the establishing of an epistemic practice. On the other hand, visual representations as tools in a practice can also be treated technically. When treated technically, visual representations are treated as unproblematic, ready-to-hand instruments, where the knowledge represented is treated as given (Ewenstein & Whyte, 2009, p. 22). In those cases, the visual representations do not necessarily encourage the establishing of an epistemic practice. This implies that visual representations as action-mediating tools have the potential to afford actions and discussions that create an epistemic practice, but they do not necessarily do so. Results presented in Paper III suggest that the causal loop diagram, to a greater extent than the graph, encouraged an epistemic practice. This became especially clear in the group discussions, where the causal loop diagram encouraged further questions and reflections and afforded discussions concerning the causal relationships in pricing. As a consequence, the loop diagram functioned as a means for developing an understanding of pricing. In contrast, the graph tended to function as an objective in itself, considered as a given ready-to-hand instrument that needed to be decoded, learnt and understood ‘in the right way’. This
relates back to the risks highlighted earlier. The risk of ending up with a focus on how to understand and manipulate the form (the representation itself), rather than on how to understand the conception or phenomena (risk 1 mentioned above), seems to be greater when the visual representation is treated technically. In this study, this happened with the graph. This could be compared with the causal loop diagram groups, where the visual representation encouraged problematizing and unfolding the causal relationships in pricing, resulting in a more epistemic practice. The compositional structure of the visual representation thus seemed to matter for how the representation was treated in the practice – epistemically or more technically. The compositional structure also seemed to matter in terms of the second risk mentioned above - students’ misunderstanding of the inner workings of a phenomenon and drawing simplified or mistaken conclusions. This risk became more evident when the visual representation used was treated technically, as was the case with the graph. In the causal loop diagram groups, the visual representation was used to problematise simplified and mistakenly drawn conclusions, which afforded more of an epistemic practice.

It could thus be helpful, in the strive to avoid the risks mentioned above, to consider visual representations as potential tools in the establishing of an epistemic practice. The graph has the potential to contribute to the establishing of an epistemic practice, encouraging further unfolding of the concept of pricing. However, in this study, the graph was rather treated technically, by teachers as well as students.

**Understanding visual representations as facilitating critical aspects of the phenomenon to be discerned**

The third risk mentioned above focuses on the risk of teaching using simplified visual representations without really knowing to what extent, or in what way, they facilitate, or even hinder, a complex and qualified understanding of the content. One possible way of dealing with this risk is thinking about visual representations as illustrations bringing forth, or making explicit, critical aspects of a phenomenon that students need to discern in order develop a more qualified conception of the phenomenon illustrated. Results from Paper II suggest that the two visual representations to different extents facilitate for students to discern critical aspects of causality in pricing. This could be seen as an explanation of why students in the causal loop diagram-based groups developed more qualified conceptions of pricing than the graph-based groups. If we can identify which critical aspects of a phenomenon are highlighted by different visual representations, we can become more efficient in using them to help students develop qualified conceptions of complex and dynamic phenomena, concepts and structures focused in social science. This might be especially relevant when using simplified illustrations of complex structures and phenomena. With this view of visual representations, the compositional structure of a visual representation becomes crucial for how the content is understood. The possible relation between critical aspects and teaching and learning...
through visual representations will be further discussed in Chapter 8 (in the section “Phenomenography, variation theory and visual representations”).

What role does the compositional structure play?

To summarise, the compositional structure plays an important role in qualifying students’ conceptions of causation in pricing and in establishing teaching-learning practices. Using visual representations to simplify complex and dynamic phenomena and concepts is often helpful, but also involves risks and teaching challenges. Those challenges, as well as the role of the compositional structure of a visual representation, could be understood from different viewpoints, of which three have been discussed here: visual representations as more or less disciplinary rationalised, visual representations as potential tools in the establishing of an epistemic practice and visual representations as facilitating critical aspects of the phenomenon visualised. From each of these viewpoints, the compositional structure seems to play a central role for the practices established in the classroom and for students’ understanding of the content.

Challenge 2: Different goals of a visual representation - when used in the discipline and when used in social science teaching

As was pointed out in the introduction, many of the visual representations used in teaching and learning are drawn from the discipline(s) to which the school subject relates, something which entails both possibilities and challenges. One possibility, as has been earlier described, is the central role disciplinary models and representations play in mastering a discipline (Airey & Linder, 2009; Davies & Mangan, 2013). Learning in a certain knowledge domain could be described as developing the ability to handle, or coming to appropriately interpret and use, different established tools or semiotic resources (Airey & Linder, 2009, 2017; Selander, 2008). Disciplinary models may carry the potential to convey and visualise the core of a subject content necessary for students to grasp. A challenge, however, as has been mentioned in the introduction, is that the goal of a visual representation when it is used within a discipline is not necessarily the same as the goal when it is used in teaching a school subject. There may thus be a difference, that the teacher needs to be aware of and deal with, between the goal of a disciplinary developed visual representation when used in the discipline and when used for instructional purposes in social science teaching. This assumption takes its outset in a practice theory perspective, as explained in more detail in Chapter 4. One of the research questions raised in this thesis focuses on the relationship between (i) the goal of a visual representation when it is used within an economics discipline and
(ii) the goal when it is used in social science teaching in upper secondary school. The research question focuses on what role this relationship plays for what learning of causality is made available for students learning about pricing. This question contains the challenge of a potential difference in goals, as discussed above, and the discussion below will shed light on and give some potential answers to this question.

In the following sections, I will first discuss why a difference in terms of goals (in the discipline where it was developed and in upper secondary social science education) of the visual representation could be considered problematic. I will then discuss how the results from Papers II and III, focusing on visual representations of pricing, could be understood in light of the goal of the visual representation. The perspective on the results offered in this section may be seen as complementary to the explanation focusing on compositional structure above. The relationship between learning and the use of visual representations is complex, and several different perspectives may be taken into account. Finally, I will discuss the use of disciplinary developed visual representations in social science education in general.

Different goals in the use of visual representations – why problematic?

In the introduction chapter, it was highlighted that social science as a school subject in Sweden serves a different purpose than the disciplines, in terms of social science having a broader purpose through for instance the serving of societal, cultural and individual expectations (Nordgren, 2017; Sandahl, 2018). In that sense, what is focused upon and highlighted in social science education may have a different rationale compared to a disciplinary rationale, although the subject content focused upon in social science stems from the different disciplines. This implies, which is central in a practice theory perspective, that disciplinary developed visual representations serve a certain purpose in the discipline, but may be used in social science education to serve a different purpose. I have in the introduction chapter, as well as above, expressed that this difference in goals needs to be considered. But why so? I would like to discuss this question in terms of different practices.

A social science upper secondary classroom and a disciplinary setting generally represent different practices. A practice can be defined by identifying what the actors want to accomplish, thus what is going on and why, and are realised through goal-oriented actions (Eriksson & Lindberg, 2016). In a social science classroom, the purpose is often rather different from the purpose in a disciplinary practice, as has previously been discussed. When a visual representation is developed and used in a practice, the visual representation is often intended to support the purpose aimed for in that particular practice. This implies that if a visual representation is developed with one goal in one practice, it is not necessarily easily transformed to serve a different goal in a different practice. Accordingly, the fact that a certain visual representation facil-
itates the realization of one particular purpose in one practice (such as understanding systems on an aggregate level, solving problems or making calculation and predictions within a disciplinary practice) does not necessarily imply the facilitation of another purpose in a different practice (such as learning complex relations in an educational practice). This challenge could be identified in social science teaching: a visual representation that stems from an academic discipline may be used in the discipline with one goal, but due to the broader purpose of the school subject, be used with another goal in the instructional setting, something which may cause problems in the learning situation. This challenge could be understood in terms of a difference between what one aims to accomplish through the use of the visual representation. Problems may thus arise when adopting a visual representation from one practice to another, if what one aims to accomplish through the visual representation differ between the practices where it is used. This will be further discussed below in relation to the results from Paper II and III.

The supply/demand graph and causal loop diagram as examples

The results from Papers II and III showed that the causal loop diagram to a greater extent than the supply/demand graph facilitated students’ developed conceptions of causation in pricing as well as epistemic teaching-learning practices to be established in the classroom. As mentioned earlier, the supply/demand graph and the causal loop diagram do not only differ in terms of compositional structure, that is what critical aspects are being made explicit and thus what aspects are visually placed in the foreground versus background. They also differ in terms of what purpose they serve in a disciplinary setting, where they both were developed. The supply/demand graph is a disciplinary developed visual representation that stems from economics and aims at illustrating the function of a whole economy on an aggregate level, the mathematics behind pricing and price elasticity, thus explain where and how price emerges. The causal loop diagram is also a disciplinary developed visual representation but stems from system dynamics. This representation was disciplinary developed in order to help undergraduates grasp the dynamic relationships in pricing: “Its purpose is to enable undergraduates to discover dynamics even when they lack the mathematical tools that advanced students use to explore that vast - and politically relevant - territory between the shores of equilibria.” (Wheat, 2007a p. 391).

This difference in goals is a possible additional explanation to the results identified in Paper II and III. The goal of the lessons conducted as part of Paper II and III was to help students develop an understanding of causality in pricing, thus how supply, price and demand relate to each other. This goal corresponds with that of the causal loop diagram. The purpose behind the causal loop diagram, when developed and used within the discipline, was the same as when teaching upper secondary students. Accordingly, there was no difference in the purpose of the use of the visual representation when used and
developed within an economics disciplinary practice and in an upper secondary classroom. In both cases, the goal was to help students develop an understanding for dynamic relationships in pricing. The two practices where the visual representation was used were thus similar, sharing a similar purpose, aiming at a similar goal. This could be a possible explanation to why the causal loop diagram facilitated for students to develop more qualified conceptions of causality in pricing: what the visual representation aimed to illustrate in the social science lesson corresponded with the purpose of the visual representation in the practice where it was first developed and used. In contrast, there seems to be a difference in goals when supply/demand graphs were used in the social science classroom. Focus in the lessons was causality in pricing, whereas the graph has been developed to illustrate something wider—the function of a whole economy on an aggregate level, the mathematical structures behind price, elasticity, and where and why price emerges.

In sum, on the basis of what has just been said about the purpose of the two used and disciplinary developed visual representations, it is not surprising that the causal loop diagram to a greater extent than the supply/demand graph facilitated for students to develop more qualified conceptions of causality in pricing. The results presented in Paper II and III could be understood as examples of the importance of using a visual representation for the same purpose when adopting a visual representation from one practice to another.

Should we use disciplinary developed visual representations in social science teaching?

In the introduction chapter, I raised some different perspectives on social science as a multidisciplinary school subject without one clear disciplinary residence. The relationship to different disciplines which characterises social science has by some been considered problematic (see, for instance, Barr et al., 1977; Bronäs & Selander, 2002), but by others its strength (see, for instance, Barton & Avery, 2016; Olsson, 2016). I highlighted a third possible view in this matter: the multidisciplinary residence for social science as a strength that entails certain challenges that need to be dealt with. The use of disciplinary developed visual representation in social science teaching is one such challenge, as discussed above. So, should disciplinary developed visual representations be used in social science teaching? I would like to discuss this question in terms of two different, but related, answers: ‘it depends’ and ‘yes, but’. I would also like to discuss this question somewhat rephrased, adding a ‘how’ to the question: How should we use disciplinary developed visual representations in social science teaching?

A first answer to the question whether or not disciplinary developed visual representations should be used in social science teaching is ‘it depends’. This relates to what was discussed in the two former sections – it depends on what one tries to accomplish through the use of the visual representation. If there is
a correspondence between the purpose of the visual representation when developed and used within the discipline and the purpose for which it is used in the social science teaching situation, the use of disciplinary developed representations may be very fruitful, although they may need a thought through ‘unpackaging’ (Fredlund et al., 2014). However, if there is a difference in goals, the use of those visual representations may not be very fruitful, despite careful ‘unpackaging’. It may be that in order for students to understand different important structures and concepts in for instance economics, other visual representations than the disciplinary, traditionally used, visual representations need to be used in teaching. The ‘it depends’-answer thus demands of the teacher to reflect on the different visual representations at hand and decide whether or not they serve the same goal as the lesson aims at accomplishing. This could be related to what Airey and Linder (2017) highlight in terms of disciplinary affordance and pedagogical affordance, thus the meaning making potential of a visual representation in a disciplinary community and its usefulness for teaching and learning a certain content. What Airey and Linder do not do, but which I think could be done, is understanding the relation between disciplinary affordance and pedagogical affordance in terms of corresponding or not corresponding purposes in the different practices where the visual representation is used. If the goal of using the visual representation in one practice (such as a disciplinary practice) corresponds with the goal of using it in another (such as a social science education practice), the disciplinary affordance and the pedagogical affordance may be corresponding, which in turn may further facilitate learning. In that sense, focus in the learning situation should thus not merely be on the correspondence between the disciplinary meaning potential, thus the ‘disciplinary affordance’, and the individual student’s experiencing of the visual representation, as highlighted by Airey and Linder (2017), but on the correspondence between the goal(s) with which the visual representation is used in the different practices.

A second answer to the question could be ‘yes, but’. It could be argued, as has been mentioned earlier, that in order to master a discipline, one also needs to master its visual language, for instance disciplinary relevant and central visual representations (Airey & Linder, 2009, 2017; Davies & Mangan, 2013; Selander, 2008). In that sense it is important to introduce and use core representations from relevant disciplines in social science education, as the purpose is for the students to become social science literate, which includes also visual aspects (Sandahl, 2015). In that sense, the answer to the question of using disciplinary developed visual representations in social science teaching is yes, however there is also a ‘but’, which is related to the ‘it depends’ discussed above. There are several different keys to handle this ‘but’, thus how to introduce and use disciplinary developed visual representations in teaching and learning in a fruitful way. Based on the results from the studies included in this thesis, reflecting on the goal of the use of the visual representation, is a central key.
One way of dealing with the question raised in this section is to add a ‘how’ to the question – *how* should or could disciplinary developed visual representations be used in teaching in a fruitful way? Reflecting on the goal of the visual representation when used in the disciplinary domain where it was developed in relation the goal it aims to fulfil in the teaching situation, is one way of going about the ‘how’-question. Another way of going about it is to reflect on when and how those visual representations should be introduced. Disciplinary visual representations are not always suitable to start with when introduction novices to a field, but could rather be introduced as a second step. For instance, Airey and Linder (2017, p. 119) argue that “there is a specific set of aspects that make up each disciplinary concept, and that different semiotic resources, with their different disciplinary affordances present different possibilities to represent these aspects”. With this argumentation, the two different visual representations of pricing, the causal loop diagram and the supply/demand graph, visualise different aspects of pricing and if introduced and unpacked in a thought through way, they may together give the students a richer understanding of pricing. General conclusions concerning this cannot be drawn based on the results presented in this thesis, but the results raise these questions and future research could take this issue further. However, it is relevant and important to reflect on, problematise and discuss the role of the disciplinary developed and traditionally used visual representations in teaching and learning in social science.

What role does the goal of a visual representation play?

To summarise, the relation between (i) the goal of a visual representation when it is used within an economics discipline and (ii) the goal when it is used in social science teaching in upper secondary school, seems to play an important role for what learning of causality in pricing is made available for students. This could be understood in terms of the different practices where the representation is used. The results presented in Paper II and III could be understood as examples of the importance of corresponding purposes when adopting a visual representation from one practice to another. This highlights the importance for the teacher to reflect on the different visual representations often used in teaching in terms of to what extent they serve the same purpose as the teaching aims to accomplish.
In this final chapter I will extend the discussion and make some concluding remarks. I will first discuss and relate two different theoretical perspectives on learning through visual representations (a cognitive psychology perspective and a practice theory perspective). Such a discussion could shed light on how different theoretical perspectives are needed in order to further understand learning through visual representations. I will then discuss how phenomenography and variation theory, with a special focus on the notion of ‘critical aspects’, can be a useful theoretical perspective on learning through visual representations. The final sections will deal with relevance for teaching and learning in social science education, practical implications and a discussion of theoretical, empirical and practical contributions of this thesis.

Different theoretical perspectives on learning through visual representations

Much of the earlier research on visual representations and teaching and learning takes a cognitive psychology perspective. The focus in this tradition lies chiefly in if or to what extent a visual illustration contributes to learning. This dissertation builds on a licentiate thesis with a cognitive perspective on learning with visual representations. In order to deepen and broaden the understanding of how visual representations can facilitate learning in social science, this thesis applies other theoretical perspectives on learning through visual representations: phenomenography in combination with variation theory and a practice theory perspective. With those theoretical perspectives this thesis contributes with insights into classroom practice in terms of what learning of a particular subject content a certain representation facilitates and how it is understood by the students, as well as what teaching-learning practices are established through the use of a certain representation, knowledge of great importance when trying to help students develop a complex conception of a content by using visual representations.

In this section, I will place a cognitive psychology perspective, which was applied in the licentiate thesis, and a practice theory perspective, applied in the doctoral thesis, next to each other and discuss them in terms of limitations
and possibilities in relation to teaching and learning through visual representations. I will also raise the question concerning in what way the two perspectives can be considered complementing and/or contradictory. Such a comparison and discussion is important for several reasons. First, as much of earlier research takes a cognitive perspective on learning through visual representations, a discussion on the possibilities and contributions from other theoretical perspectives could be fruitful. Second, from a practitioner perspective, it could be fruitful to consider what the different theoretical perspectives highlight and can contribute with in relation to the use of visual representation in the teaching and learning situation. Both a cognitive psychology perspective and a practice theory perspective have traditionally paid attention to learning through visual representations and thus explicitly ascribe visual illustrations an important role in learning. Phenomenography and variation theory have paid limited attention to the relationship between learning and visual representations (but see, for instance, Booth & Ingerman, 2008; Fredlund et al., 2015a; Ingerman et al., 2009). However, this tradition has great potential to add to our understanding of teaching and learning through visual representations. This contribution will be discussed in the section “Phenomenography, variation theory and visual representations” below.

The two perspectives discussed

Both a cognitive psychology perspective and a practice theory perspective deal with the relationship between visual representations and teaching and learning. They offer perspectives on what a visual representation can contribute with, or hinder, in a teaching and learning context. Placing those theoretical perspectives next to each other opens up for an interesting, and I think important, discussion on teaching and learning through visual representations. Before introducing such a discussion, two things are worth mentioning. First, there are obviously more theoretical perspectives having an interest in the use and role of visual representations, than the ones discussed here. However, I found those two theoretical perspectives suitable, as they both focus on learning, as well as the role of the visual representation in teaching and learning. Second, as mentioned earlier in the introduction to the theory section, Stiles (2009, p. 9) defines scientific theories as “descriptions of aspects of the world…. (that) knit observations together, suggesting how observations of one thing may indicate that other things have taken place or will take place”. A cognitive psychology perspective and a practice theory perspective differ both in terms of what ‘aspects of the world’ are focused upon, as well as in terms of what patterns and techniques should be used when ‘knitting observations together’ and the foundational ideas of knitting. My ambition is not to knit the two theoretical perspectives together. Given the contradictory epistemological and ontological assumptions of the perspectives, which I will come back to below, such an ambition would be impossible. Instead, my ambition is to discuss two theoretical perspectives on learning through visual representations,
knitted with very different techniques and foundational ideas of knitting, in order to shed light on the challenges and possibilities involved in using visual representations in teaching and learning. With that starting point it is possible to discuss limitations and possibilities with the different perspectives.

Limitations and possibilities
A cognitive psychology perspective and a practice theory perspective will here be discussed in terms of what limitations and possibilities they have in explaining/understanding the role of visual representations in teaching and learning in social science. I would like to discuss this matter in relation to five aspects that are central in trying to identify possibilities and limitations (see row 1-5 in Table 9 below). Those five aspects are:
1. Central idea of learning
2. The role of a visual representation in teaching and learning
3. What the visual representation is seen in relation to
4. Why the compositional structure of a visual representation matters
5. The role of the subject content

I will give a brief overview of how the two theoretical perspectives could be understood in relation to the five aspects, before discussing limitations and possibilities in light of those aspects.

Five aspects of learning through visual representations, central for limitations and possibilities
First, the central idea of learning is very different in a cognitive psychology perspective and a practice theory perspective. In the former, knowledge is considered being an individual property and learning is understood as mental processing of information (Mayer, 2010; Paivio, 1986). In the latter, knowledge is considered to be constituted in, and actualised through, people’s actions, and learning could be understood as a changed participation in social contexts, thus mastering a practice (Knorr Cetina, 2007; Lave & Wenger, 1991; Radford, 2015). This implies that in the former, learning is defined relative to self-contained structures, whereas in the latter it is defined relative to actional contexts (Lave & Wenger, 1991).

Second, the two theoretical perspectives have rather different views on what role the visual representation plays in teaching and learning. From a cognitive psychology perspective, cognitive theory of multimedia learning (CTML) suggests that a visual representation is an important complement to written or spoken text, as it facilitates information to be processed in two different channels simultaneously, a verbal and a visual, which strengthens learning in terms of both verbal and visual representations being created and integrated (dual coding theory: Mayer, 2009; Paivio, 1986). From a practice theory perspective, visual representations are considered an action-mediating tool (Wertsch, 1998), highlighting certain aspects of the subject content illustrated,
which in turn facilitates, or affords, different actions and thus affects what is made possible for students to learn (Danielsson & Selander, 2014; Ewenstein & Whyte, 2009; Kress & Van Leeuwen, 2006; Selander, 2009).

Third, the theoretical perspectives also differ in terms of what the visual representation is seen in relation to. From a cognitive psychology perspective, the relationship focused upon is that between the visual representation and mental processing of information. In a practice theory perspective, focus is rather placed on the relation between the visual representation as a tool and the actions mediated/afforded by this tool, and thus the practices established.

Fourth, both perspectives have their view on why the compositional structure of a visual representation matters. From a cognitive psychology perspective, the compositional structure can either hinder or help the processing of information: it can either cause cognitive overload, as the two channels have limited capacity (Baddeley, 1992; Sweller, 2010), or help the learner to pay attention to and organise relevant information (Brody, 1982; Peeck, 1993). From a practice theory perspective, different tools afford different actions (Ewenstein & Whyte, 2009) and thus have different potentials to facilitate learning. The compositional structure of a visual representation, thus what aspects of the phenomenon illustrated are brought to the fore or held in the background, is therefore crucial for what actions are afforded.

Fifth, the role of the subject content is different in the two theoretical perspectives. In cognitive psychology, the subject content is somewhat secondary, as it is rather the general principles and processes involved in learning with visual representations that are in focus. In a practice theory perspective, the subject content is central and visual representations as action-mediating tools are central in terms of what actions are afforded and thus what learning of the subject content are made possible.
Table 9. Summary of aspects on learning through visual representations, as understood from two different theoretical perspectives.

<table>
<thead>
<tr>
<th></th>
<th>Cognitive psychology (cognitive theory of multimedia learning, CTML)</th>
<th>Practice theory perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central idea of learning</td>
<td>Learning as mental processes/information processing</td>
<td>Learning as mastering a practice</td>
</tr>
<tr>
<td>The role of a visual representation in teaching &amp; learning</td>
<td>A complement to written/spoken text</td>
<td>An action-mediating tool</td>
</tr>
<tr>
<td>What the visual representation is seen in relation to</td>
<td>Mental information processing</td>
<td>The actions mediated/afforded and teaching-learning practices established</td>
</tr>
<tr>
<td>Why the compositional structure of a visual representation matters</td>
<td>Depending on the compositional structure, a visual representation may either cause cognitive overload, or help the learner to pay attention to and organise relevant information, as well as integrate it with prior knowledge</td>
<td>Different visual representations of a content afford different actions, for instance as different aspects of the content are visually placed in the foreground or background, and different visual representations can have different potentials to facilitate learning</td>
</tr>
<tr>
<td>The role of the subject content</td>
<td>Peripheral – focus is on general guidelines for compositional structure, regardless of subject content visualised</td>
<td>Central - focus is on the relation between the compositional structure of the visual representation and the actions afforded in relation to the subject content visualised</td>
</tr>
<tr>
<td>Implications for teaching and learning</td>
<td>Use visual representations as a complement to text (written or spoken) in teaching and learning, as the combination of words and pictures enhance learning, but make sure the representations used do not cause cognitive overload</td>
<td>Think about visual representations as action mediating tools, thus affording different actions, and focus on creating conditions for the visual representations used in teaching and learning to encourage epistemic practices to be established</td>
</tr>
</tbody>
</table>

Limitations and possibilities in the theoretical perspectives applied
All theoretical perspectives have possibilities and limitations. The possibilities created by a theoretical perspective may also create its limitations. I will now briefly discuss some limitations and possibilities related to the two theoretical
perspectives. As we will see, limitations and possibilities are in some cases two sides of the same coin.

A possibility in a cognitive psychology perspective is its potential to provide general principles concerning teaching and learning with visual representations. One such general principle is that visual representations should be used as a complement to written or spoken texts in the learning situation. Another general principle concerns how a visual representation should be composed in order to efficiently support the learning process. For instance, research in this field has resulted in a list of principles guiding how a visual representation should be designed in general terms, in order to avoid cognitive overload (Levin & Mayer, 1993; Mayer, 2009, 2011). These principles are considered general and applicable to any content, thus not subject specific. The focus on general principles, which could be described as this theoretical perspective’s possibility, is also, I would argue, this perspective’s major limitation. Knowing that a visual representation facilitates the learning process in general does not provide insights concerning learning through visual representations in relation to different specific subject contents. When the subject content becomes peripheral in a theoretical perspective, as is the case in cognitive psychology, there are clear limitations in terms of its usefulness for teaching and learning. The challenges in the classroom often lie in helping students to develop a qualified understanding of complex issues. A theoretical perspective providing general guidelines, such as the importance of using visual representations and general design principles, does not necessarily offer what is needed in that situation. Another limitation in a cognitive psychology perspective is its focus on mental processes. Although it could be argued that this focus opens up for general principles, it is limited in that it only takes into account the relation between the visual representation used and mental information processing. Defining learning as information processing automatically excludes several aspects of the relationship between visual representations and teaching and learning. These limitations in the cognitive psychology perspective were one of the starting points for this doctoral thesis, as described earlier. Although interesting conclusions were drawn in the licentiate thesis concerning the impact of including a visual representation in upper secondary psychology teaching, the conclusions drawn were rather general. General conclusions and principles can be useful, but need to be complemented with more subject specific conclusions and guidelines.

Many of the possibilities created by a practice theory perspective arise from the centrality of subject content. A visual representation becomes something more than a general addition to the spoken or written text. It becomes a tool in the learning situation which can highlight certain aspects of the subject content and afford different actions and thereby facilitate learning. A focus on compositional structure in relation to the subject content visualised is an important possibility and could be compared to a cognitive psychology perspective where the compositional structure of a visual representation rather is related to general principles. Also, whereas a cognitive psychology perspective
has its main focus on the individual in relation to the visual representation, a practice theory perspective focuses on social practice. Learning is understood as changed participation in social contexts and coming to master a practice. This focus on learning as practice participation is one of the major possibilities with this perspective in relation to learning and visual representations. When a visual representation is being considered as an action-mediating tool, other aspects of the role of a visual representation in teaching and learning are possible to grasp. For instance, a visual representation is understood not only in relation to students’ understanding or conception of the phenomena, but also in relation to what actions it affords. As learning is considered to be embedded in actions, visual representations as action-mediating tools become central in the learning process.

In sum, no single theoretical perspective can provide the full picture of a phenomenon, but each theoretical perspective can contribute with useful insights to a phenomenon. The discussion above exemplifies this.

Complementing or contradictory?

As mentioned above a cognitive psychology perspective and a practice theory perspective are very different in terms of ontological and epistemological assumptions. Knowledge and learning are thus considered and defined in fundamentally different ways within the two theoretical perspectives. This raises questions concerning in what way the theories are contradictory and in what way the theories can be considered complementing. I would like to discuss this in light of the two perspectives’ ideas of knowledge and learning and their implications for teaching (row 1 and 6 in Table 9 above).

The foundational assumptions concerning knowledge and learning (row 1 in Table 9) are fundamentally different in cognitive psychology and a practice theory perspective. In that sense, those two theories are contradictory. In the former, holding a more traditional rationalistic view on knowledge and learning, knowledge is considered propositional. With this view, mind and body are seen as a dichotomy and learning is understood as mental processing of information, thus something that happens ‘in the head’ of the individual. In the latter, knowledge is considered to be constituted in, and actualised through, people’s actions. There is thus no dichotomy between mind and body and learning is understood as a changed participation in social practices, mastering a practice, or mastering specific ways of seeing or being in the world. This implies that a cognitive psychology perspective and a practice theory perspective are incompatible and contradictory. Arievitch (2017) discusses this contradiction further in his book and problematises the biological reductionism and ‘brainism’ that has come to dominate much of contemporary psychology and education. He suggests that this ‘brainism’ has led to a misleading objectification of psychological phenomena, such as mental representations, memory and thinking.
Despite the major differences in foundational assumptions, both perspectives offer implications for teaching (row 6 in Table 9). These implications could, from a teacher profession perspective, be considered complementary, as they offer different, but relevant, aspects to consider when using visual representations in teaching and learning. Implications from a cognitive perspective include the importance of using visual representations in teaching, as the visual representation has the potential to further strengthen the learning process and focus attention. A cognitive psychology perspective also highlights the importance of considering how much information a visual representation contains, as too much information in one illustration may be counterproductive in the student’s learning process. A practice theory perspective complements a cognitive psychology perspective by bringing in actions and practices established as central aspects of learning through visual representations. In considering visual representations as action-mediating tools, which in turn make up practices, this perspective offers implications for teaching that go beyond a cognitive psychology perspective. These implications include for instance considering visual representations as action-mediating tools, thus affording different actions. They also include the importance of trying to create conditions for the visual representations used to contribute to an establishing of epistemic practices in the classroom. The implications also include the importance of the compositional structure of the visual representation from a subject content perspective. It is not enough to know that the compositional structure of a visual representation matters in terms of how much information is included, but also in terms of what aspects are facilitated for the students to discern.

To summarise, a cognitive psychology perspective and a practice theory perspective are foundationally contradictory in terms of ontological and epistemological assumptions. Nevertheless, the different theoretical perspectives have the potential to be complementing from a practitioner point of view, as both perspectives offer aspects of learning through visual representations that are relevant in the teaching situation.

Phenomenography, variation theory and visual representations

This thesis uses phenomenography as a theory of learning and as a method for analysing students’ conceptions of causality in pricing (Paper I) and it uses variation theory as a theory of teaching and learning that enables us to identify critical aspects highlighted in different visual representations of pricing (Paper II). Phenomenography in combination with variation theory has not been a frequently used framework in previous research on learning through visual representations (but see, for instance, Booth & Ingerman, 2008; Fredlund et al., 2015a, 2015b; Ingerman et al., 2009). Nor have different compositional
structures of a visual representation been a main focus in earlier phenomenographic or variation theory research. The potential of this theoretical perspective for understanding the role of visual representations in teaching and learning is yet to be fully exploited. This thesis, especially Paper II, shows how phenomenography in combination with variation theory provides a fruitful way of analysing the relationship between learning and different visual representations of a specific content. In the following section, I will discuss why phenomenography in combination with variation theory can be a useful perspective for analysing visual representations in teaching and learning. I will also argue that phenomenography, in combination with variation theory, can make an important contribution to research on teaching and learning through visual representations.

Phenomenography/variation theory as a useful theory for analysis of visual representations

I would like to emphasise three ways in which phenomenography and variation theory can be a useful perspective when analysing visual representations in teaching and learning and thus contribute to the research field of learning through visual representations.

First, variation theory, with a focus on the notion of ‘critical aspects’, could be a helpful tool for identifying critical aspects that are, or are not, made possible to discern through different visual representations of the same content. A phenomenography and variation theory framework provides a way of investigating how different visual representations affect learning by bringing different dimensions of a phenomenon into focus. As we have seen above, it has been suggested that different visual representations highlight different parts of the content illustrated and this affects what is being communicated and thus what learning is facilitated (Danielsson & Selander, 2014; Kress & Van Leeuwen, 2006; Selander, 2009). This conclusion is similar to conclusions drawn from a phenomenography and variation theory perspective. However, a variation theory framework provides methods for identifying in more depth what is and what is not made possible to discern in different representations, as well as why, in terms of critical aspects being made visible or not. This is a possibility which has also been highlighted by other scholars (see, for instance, Booth & Ingerman, 2008; Fredlund et al., 2015a; Ingerman et al., 2009). Also, an analysis of critical aspects made visible allows the researcher to analyse not only if a visual representation facilitates learning or not, but what understanding it facilitates or even hinders, in terms of how different visual representations of a content bring different dimensions of a phenomenon into focus. In that sense a phenomenography and variation theory framework could offer an important contribution to for instance a cognitive psychology perspective on learning through visual representations, as this latter perspective often focuses on if, or to what extent, a visual representation facilitates learning. Identifying critical aspects in relation to visual representations
could be helpful both in creating visual representations of a certain subject content, as well as in evaluating the ones traditionally used in teaching of different topics. This is an important contribution to a research field often focusing on the extent to which a certain illustration, or illustrations in general, contribute to student learning.

Second, a phenomenography and variation theory framework takes students’ conceptions as starting point in the discussion of visual representations. Van Dijk and colleagues (2003) underline the importance of visual representations being designed in a way that captures students’ (rather than professionals’) understanding. Students do not necessarily see in a representation what professionals see in it. This is a general challenge in working with visual representations in education – most representations are created from a professional’s point of view, but are used with the aim of helping novices to grasp a certain phenomenon or concept. Students’ conceptions of the phenomenon seldom form the basis for the compositional structure of the illustration used. As critical aspects are identified through an analysis of students’ conceptions of a phenomenon, forming or choosing visual representations based on critical aspects could be very helpful and could be a contribution to the field of teaching and learning through visual representations. If, through phenomenography and variation theory, we identify aspects critical for students to discern, we might get new insights on how best to design visual representations in order to further develop students’ conceptions of the phenomenon. We could then possibly also reduce the risk of using visual representations that do not facilitate learning the way we want them to, or believe they do. Taking students’ conceptions of a phenomenon as a starting point when choosing or creating a visual representation for educational purposes is an important contribution that a phenomenography and variation theory perspective can offer.

Although critical aspects are traditionally identified through an analysis of students’ conceptions of a phenomenon, Fredlund and colleagues (2015b) suggest that critical aspects, or ‘disciplinary relevant aspects’, could be identified through the visual representations themselves, using a social semiotics perspective. This is something rather different from what is suggested in this thesis, as identifying critical aspects directly from a visual representation does not involve an analysis of students’ conceptions of a phenomenon.

Third, a phenomenography and variation theory perspective can also be used in order to identify students’ understanding of the role of the visual representation, as suggested by for instance Booth and Ingerman (2008). Students’ understanding of the role of the visual representation can be crucial for how the representation is being used in the learning situation.

Aspects on learning through visual representations – from a ‘critical aspects’ point of view

As can be seen in Table 10 below, phenomenography in combination with variation theory, with a special focus on the notion of ‘critical aspects’, could
relate to the aspects on learning through visual representations pointed out in Table 9 above. The notion of ‘critical aspects’ could be considered a useful tool for analysing the relationship between visual representations and teaching and learning, as it has the potential to unfold the compositional structure of a visual representation in a very subject specific way. The idea of critical aspects can thus contribute with a tool for analysis of content specific aspects being possible or not possible for students to discern. I would thus argue that phenomenography and variation theory can be relevant for and can be contributing to the research field of learning through visual representations.

Table 10. Summary of aspects on learning through visual representations, as understood from a phenomenography and variation theory perspective, with a focus on the notion of ‘critical aspects’.

<table>
<thead>
<tr>
<th>Critical aspects</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The role of a visual representation in teaching &amp; learning</td>
<td>A tool for making critical aspects of a phenomenon explicit and discernible</td>
</tr>
<tr>
<td>What the visual representation is seen in relation to</td>
<td>The learner’s discerning of critical aspects of the phenomenon visualised</td>
</tr>
<tr>
<td>Why the compositional structure of a visual representation matters</td>
<td>Different compositional structures of a subject content facilitate for students to discern different critical aspects of the phenomenon, as different compositional structures bring forth, or make explicit, different critical aspects of the content illustrated</td>
</tr>
<tr>
<td>The role of the subject content</td>
<td>Central – focus is on the relation between the compositional structure of the visual representation, thus the critical aspects facilitated for students to discern, or variation made explicit, and the learner’s conception of the subject content visualised</td>
</tr>
<tr>
<td>Implications for teaching and learning</td>
<td>Pay attention to what critical aspects of a phenomenon that seem to be facilitated, or not facilitated, through visual representations used, as this will affect the qualification of students’ conception of the content visualised</td>
</tr>
</tbody>
</table>

Relevance for social science education

Results from the studies included in this thesis specifically focus on teaching and learning of causation in pricing in economics. However, the conclusions drawn are highly relevant for social science teaching and learning in general. In the following sections I would like to raise some aspects worth reflecting
on in relation to social science education. These aspects concern (i) interrelations at the core of social science, (ii) the visual representation as an action-mediating tool, (iii) the importance of the compositional structure of a visual representation, (iv) the importance of how a question is posed, (v) problematizing traditionally used visual representations and (vi) practical implications for teaching.

Interrelations at the core of social science
Causality, interrelations and complex processes seem to be at the core of social science. Sandahl (2015) suggests analysing causality as one of the key thinking tools necessary for students to develop in order to improve social science thinking. Likewise, Rottman and colleagues (2012, p. 929) argue that “an understanding of causal systems is crucial to explaining and predicting complex phenomena (…) in social and economic spheres” and Lundholm (2018) highlights that causality in terms of being intentional, uni- and multi directional is central when it comes to learning and understanding core concepts in social science. Pricing, focused upon in this thesis, could thus be seen as an example of a phenomenon that is frequently found in social science – a phenomenon characterised by dynamic interrelations, where relations are bidirectional rather than unidirectional and where different entities affect each other. Accordingly, I would argue that moving from a unidirectional view of causation to a systematic is critical to the development of more complex understanding of several different phenomena in social science in general, not only in pricing and economics. I would therefore suggest that the conclusions drawn, and discussions held, in this thesis concerning understanding causality in pricing, are relevant both for other aspects of economics, such as environmental costs and setting of wage rates, and for social science in general. I do not claim that critical aspects identified in relation to causation in pricing are transferable to other phenomena in social science in general, or that challenges identified in relation to understanding causation in pricing are exactly the same as challenges related to understanding causality in relation to other social science phenomena. However, I do claim that general conclusions concerning the importance of helping students develop a qualified way of seeing/experiencing/understanding causality is crucial for social science in general, as well as for understanding pricing. I would also argue that how we visualise different phenomena that deal with causality in social science will affect students’ conceptions of the phenomenon visualised, as well as the teaching-learning practices established, as was the case in teaching about pricing. This will be further discussed below.

The visual representation as an action-mediating tool
The results presented in Paper III show that visual representations play a central role in forming the teaching-learning practices established in the class-
The visual representation as an action-mediating tool, affording different actions, thus become evident. For instance, seen from the outside, students seemed to be doing the same thing in all small group discussions: discuss causality in pricing with the help of a visual representation. However, when the material was analysed in terms of communicative actions and goals driving them, it was revealed that students in the different groups, depending on what visual representation the discussion was based on, did different things and only at some occasions (mainly the ones related to the causal loop diagram), the practices established could be described as epistemic. This is an insight that is important in social science teaching and learning in general. For instance, it implies that teachers, when choosing visual tools to include in their teaching, need to consider the visual representations as artefacts that play an active role in how the teaching and communication will evolve. Teachers thus need to pay attention to what the visual representations, as action-mediating tools in a practice, afford: what communicative actions and teaching-learning practices are being established through their use. In that sense the results presented in this thesis do not merely say something about visual representations in teaching and learning about pricing, but also that the choice of visual tools used in teaching will affect the practice established and thus the knowledge made available for students to experience. Another interesting and important aspect worth mentioning in this context is presented by Ewenstein and Whyte (2009) who suggest that visual representations should not only be considered as embedding or inscribing knowledge. Rather, they suggest, “inscribing, embedding and containing is only part of the story; the other is lacking, wanting and unfolding in uncharted directions” (Ewenstein & Whyte, 2009, p. 22). Perhaps visual representations in social science in general and economics teaching in particular risk being treated as the former at the cost of the latter.

The importance of the compositional structure

Results presented in this thesis also indicate the importance of reflecting on the relationship between the compositional structure of a visual representations and what learning is facilitated, something which is further discussed in terms of “Challenge 1” in Chapter 7. Results support the idea suggested in previous literature that the composition of a visual representation can have a significant influence on how the content is understood (Danielsson & Selander, 2014; Fredlund et al., 2012; Kress, 2010; Kress & Van Leeuwen, 2006; McDermott et al., 1990). It thus seems important, in each case of the use of visual representations in social science teaching and learning, to note which aspects of the phenomenon is communicated and placed in foreground (and thereby made possible to discern) and which aspects are placed in the background. The selection of aspects to highlight affects which aspects are possible to discern. This implies that different aspects of the content may be possible to discern through different visual representations. It also implies that focus
should not only be on whether or not a visual representation is useful in teaching, but on how different visual representations are understood and what learning they seem to facilitate or afford. The results also imply that creating visual representations in a subject is a theoretical work, as it involves deciding what relations and concepts to highlight and how, a work that preferably should take students’ understanding of the conception into consideration. Those conclusions are relevant not only for teaching and learning about pricing, but for teaching and learning in social science in general.

The importance of how a question is posed

An interesting result found in Paper I concerns how a question is posed, as this will affect what dimensions of variation of a phenomenon come into view in students’ answers. This may sound obvious, however, in previous research on students’ conceptions of pricing, questions have been posed in a way that encourages students to reflect on only one dimension of variation at the time (in terms of for instance ‘What affects price?’, ‘Why has the price changed?’, etc). By using a question that opened up for students to reflect on several dimensions of variation of price at the same time (by setting problems that asked students to consider the effect of a change in one market on price a quantity in another market, as we did in this study), answers became richer. This has important implications for teaching and learning in general, as it suggests that the formulation of a question/problem posed to students needs to be given a lot of attention. The way that a problem is posed seems to substantially affect what understanding of a phenomenon or concept is being expressed by the students. This conclusion is highly relevant for research as well as teaching – in economics as well as in social science in general.

Problematising traditionally used visual representations in economics

Almost exclusively, pricing is presented visually in terms of supply/demand graphs in teaching as well as in textbooks. The supply/demand graph has become the traditional and often self-evident illustration to use when teaching about pricing (Wheat, 2007b), despite much research suggesting that this visual representation is problematic for students in the learning situation, or even counterproductive (Cohn et al., 2001; Strober & Cook, 1992). This prompts a re-evaluation of how to illustrate price in a way that is understood by the students, yet still captures the complexity of the concept (Cohn et al., 2001). This point has been discussed in more depth in relation to “Challenge 2” in Chapter 7. I do not claim that the critical aspects students need to discern in order to develop a qualified understanding of causality in pricing are not possible to discern through graphs. Indeed, there are other important reasons why graphs are useful in illustrating pricing. For example, graphs are critical for calculating elasticities and measuring the extent of changes in price, quantity and revenue. However, this research shows that novice learners frequently struggle to discern critical aspects of causality in pricing when using supply/demand graphs.
graphs. Therefore, as tools for helping novice students understand causality in pricing, the supply/demand graph needs to be problematised.

This discussion prompts a general problematising of common, traditionally used ‘institutionalised’ visual representations used in economics teaching. The strong tradition of graphical and algebraic models that have come to serve as an intellectual framework in economy (Kennedy, 2000) does not always seem to be fruitful in the learning situation and needs to be problematised. We might thus need to re-think how complex processes and relations could and should be visualised in a way that enables students to develop complex understandings of the phenomenon in focus. This holds for economics teaching as well as for teaching and learning in social science in general.

Yet another aspect, beyond the scope of this thesis, but certainly worth mentioning when problematizing the traditionally used visual representations in economics, is highlighted by Raworth (2017). In her book she argues that illustrations are very powerful storytellers, as they stick with us and shape our view of the world – what we draw determines what we can and cannot see. The way that visual illustrations are drawn in economics forms our thinking of how societies, i.e. economies, work. Visual representations of economics thus do not only affect our conceptions of the single phenomenon illustrated, but our whole view of economies and thus societies (Andersson & Öhman, 2015). We should therefore, Raworth (2017) argues, pay a great deal more attention to the pictures we draw and teach in economics. Raworth questions the whole established way of framing and thinking about economics, and thus also the way economics traditionally has been illustrated through different visual representations. The problematizing of visual representations illustrating different aspects of economics will surely continue on several levels.

Implications for teaching

The discussion above has several implications for teaching. I would like to briefly mention some such implications for teaching in social science.

1. *When helping students to understand pricing, causality is one aspect that needs to be focused upon* and teaching about pricing should facilitate for students to discern the critical aspects of causality in pricing identified in this thesis. As for social science, helping students to move from a unidirectional view of causation to a systematic and bi-directional is probably critical to the development of more complex understanding of several different phenomena in social science in general.

2. *When visual representations are used in teaching, they need to be considered as tools that play an active role in establishing teaching-learning practices in the classroom*, thus how the teaching and communication will evolve. Attention should be payed to what the visual
tools afford: what communicative actions and teaching-learning practices are being established through their use and, therefore, what learning is made possible.

3. *When using visual representations in social science teaching, it is worth reflecting on which aspects are explicitly made visible and not, as the compositional structure matters for what learning is facilitated. This implies that different visual representations of the same subject content may highlight different aspects of the relationships involved and thereby affect what understanding students develop of the phenomenon illustrated.*

4. *Creating visual representations to use in social science teaching or in course material involves deciding what relations and aspects to highlight and how.* In this process, students’ conceptions of the illustrated phenomenon, including aspects necessary to discern in order to develop a qualified understanding of the concept, should preferably be taken into account.

5. *Questions/problems posed to students need to be formulated in a way that opens up for students to reflect on several dimensions of variation of the phenomenon in focus at the same time.* Posing questions in this way, opens up for students to give ‘richer’ answers.

6. *Perhaps other visual representations than the traditionally used need to be applied in course material, as well as in teaching, in order for students to develop a complex understanding of different phenomena in social science and economics.* The notion of ‘critical aspects’ could be very helpful here, as such aspects could be guiding for what needs to be placed in the foreground and what could be placed in the background in different visual representations.

7. *It is important that visual representations used in social science teaching and learning are thought of as raising intriguing questions and opening up new ways of thinking.* There is a risk that they are thought of as primarily inscribing, embedding and containing knowledge.

**Empirical, theoretical, and practical contributions**

The contributions of this thesis are both empirical, theoretical and practical. The empirical contribution includes identifying causality as a crucial aspect for understanding pricing. This also includes the identification of an outcome space, identifying qualitatively different conceptions of casual relationships in pricing, as well as critical aspects of this phenomenon, necessary for students to discern in order to develop a more qualified conception of causality in pricing. The empirical contribution also includes insights into how a causal loop diagram, to a greater extent than a supply/demand graph, facilitates for novice students in economics to develop complex conceptions of causality in pricing.
In addition, this thesis contributes with insights into how a causal loop diagram, to a greater extent than a supply/demand graph, affords the establishing of an epistemic teaching-learning practice in the classroom.

This thesis also provides theoretical contributions. A first theoretical contribution is the finding and discussion concerning how different visual representations of the same subject content afford different actions in the teaching situation and thus affect what teaching-learning practices are established (and thus what learning is made possible). Visual representations as action-mediating tools have been highlighted in earlier research, but the role of the compositional structure in terms of the same visual representations being visualised in two different ways has not been highlighted. A second theoretical contribution is a discussion concerning how phenomenography and variation theory can contribute to a research field focusing on teaching and learning through visual representations. Third, this thesis suggests the benefits of a multi-dimensional analysis in phenomenography, where several dimensions of variation of conceptions of pricing (several separate outcome spaces) are understood in relation to each other, thus creating a multi-dimensional outcome space. By relating different dimensions of variation to each other, it is possible to get a richer understanding of conceptions of pricing, as different conceptions in different dimensions can be related to each other and understood in light of each other.

The contributions of this thesis are also practical, as several practical implications for teaching and learning in social science are identified and highlighted. The practical implications also relate to people designing course material. The practical contributions are further developed in sections above (see “Implications for teaching”).

Concluding remarks

Visual representations are frequently used in teaching and learning in social science education in order to help students develop a qualified understanding of complex processes, concepts and phenomena. This thesis highlights the potential of using visual representations in teaching and learning in social science, but it also highlights challenges involved when complex phenomena are packaged in partly simplified illustrations. In addition, this thesis illustrates how visual representations have the potential not only to help students develop a more complex understanding of different concepts and phenomena, but also how a visual representation becomes a tool that contributes to the forming of teaching-learning practices in the classroom. In that sense, visual representations have the potential to play an active role in what learning is made possible in the teaching situation.

Visual representations are a fruitful tool in teaching and learning in social science, but choosing and composing visual representations, as well as unpacking them together with students, is a delicate, important and sometimes
rather difficult job, which includes many challenges. Mun Ling and Marton (2011) talk about “the science of the art of teaching”, suggesting that quite a bit of ingenuity will be required to bring about the appropriate pattern of variation and invariance in teaching once this pattern has been identified. I would like to extend the meaning of ‘the science of the art of teaching’ to also include the art as such – the visual representations. The art of teaching could thus be understood in a double sense – both in terms of teaching as such as a craft, but also in terms of visual representations as an integral part of teaching and learning. I look forward to a further unfolding of what ‘the art of teaching’ in this latter sense may imply and entail.

To conclude, despite many challenges, there is a great potential in using visual representations in teaching and learning in social science. By making things visible, we can contribute to making learning possible.
Abstract

This thesis focuses upon the relationship between teaching and learning of dynamic phenomena and processes in social science and the use of visual representations in social science teaching. Teaching in social science uses many visual representations, such as models, flowcharts and diagrams, in order to help students to grasp phenomena, structures and processes in society. However, it is a challenge to use a visual simplification of a complex reality without reducing its complexity, and we often do not know what understanding is facilitated or even hindered through the use of different visual representations. We thus need to identify the relationship between how the content is visually illustrated and composed (compositional structure) and how students understand the content visualised. We also need to improve our understanding of the relationship between visual representations used in teaching and the teaching-learning practices established in the classroom. This thesis aims to contribute to these areas, with a focus on visual representations of pricing in economics, as an example of a complex and dynamic process in social science.

Paper I uses phenomenography and variation theory to investigate students’ conceptions of causal relationships in pricing. Causality was identified as a central dimension of variation in understanding pricing. Different conceptions of causality in pricing were identified in students’ written answers and critical aspects of causal relationships in pricing were identified. Paper II compares the outcome of using two different visual representations of pricing used in teaching. This paper draws attention to the ways in which these representations helped students to discern the critical aspects identified in Paper I. A causal loop diagram was considerably more effective than supply/demand graphs in helping students to discern the critical aspects of causal relationships in pricing. A conclusion drawn is that the compositional structure of a visual representation plays a vital role for how students understood the content visualised and which aspects of the phenomenon are more easily discerned, and which are not. The phenomenographic and variation theory analysis suggests that different compositional structures highlight variation in different dimensions of a phenomenon. Paper III uses a practice theory perspective to deepen the understanding of the results from Paper II. Results from Paper III suggest that the causal loop diagram, to a greater extent than the graph, contributed to the establishing of an epistemic practice, a practice where knowledge was developed and transformed. This was for instance seen in the causal loop diagram affording discussions concerning the causal relationships and encourag-
ing further questions and reflections. A conclusion drawn is that a visual representation as an action-mediating tool plays a central role in forming the teaching-learning practices established in the classroom.

The results from the three papers are also discussed in relation to two challenges: (i) how simplified visualisations of complex processes and structures may facilitate students developing a qualified understanding of such processes and structures and (ii) how disciplinary developed visual representations, when used in social science teaching, may be used with a different goal than when used in the discipline, where they were developed. The contributions of this thesis are both empirical, theoretical and practical and several practical implications for teaching and learning in social science were identified.
Denna avhandling fokuserar på relationen mellan undervisning och lärande av dynamiska fenomen och processer i samhällskunskap och användandet av visuella representationer i samhällskunskapsundervisningen. I samhällskunskapsundervisningen används ofta olika typer av visuella representationer, så som modeller, flödesscheman och diagram, för att hjälpa elever att utveckla en förståelse för fenomen, strukturer och processer i samhället. Det är dock en utmaning att använda visuella förenklingar av en komplex verklighet utan att samtidigt förminska dess kompleksitet och ofta vet vi inte vilken förståelse av ämnesinnehållet som en visuell representation faktiskt möjliggör eller till och med hindrar. Vi behöver därför identifiera relationen mellan hur ett ämnesinnehåll är visuellt illustrerat och strukturerat (kompositionell struktur) och hur elever förstår det visualiserade ämnesinnehållet. Vi behöver också fördjupa vår förståelse för relationen mellan visuella representationer som används i undervisningen och de undervisning-lärande-praktiker som etableras i klassrummet. Den här avhandlingen syftar till att bidra till dessa två områden, med ett särskilt fokus på visuella representationer av prisbildning, som ett exempel på en komplex och dynamisk process i samhällskunskap.

I artikel I används fenomenografi och variationsteori för att undersöka elevers uppfattningar av kausala relationer i prisbildning. Kausalitet identifierades som en central dimension av variation i att förstå prisbildning. Olika uppfattningar av kausalitet i prisbildning identifierades i elevernas skrivna svar och kritiska aspekter av kausala relationer i prisbildning identifierades utifrån dessa uppfattningar. I artikel II jämförs resultatet av att använda två olika visuella representationer av prisbildning i undervisningen. Denna artikel fokuserar på hur dessa representationer hjälpte elever att urskilja de kritiska aspekter som identifierades i artikel I. Ett loop-diagram hjälpte eleverna i betydligt större utsträckning än grafer att urskilja kritiska aspekter av kausala relationer i prisbildning. En slutsats som dras är att hur en visuell representation är utformad spelar stor roll för hur elever förstår det ämnesinnehållet som illustreras och vilka aspekter av fenomenet som lätt kan urskiljas och inte. Den fenomenografiska och variationsteoretiska analysen föreslår att olika sätt att illustrera ett och samma ämnesinnehåll synliggör variation i olika dimensioner av ett fenomen. I artikel III används ett praktikteoretiskt perspektiv för att fördjupa förståelsen av resultaten i artikel II. Resultaten i artikel III visar att ett loop-diagram i större utsträckning än grafer bidrog till etablerandet av en epistemisk praktik, d.v.s. en praktik där kunskap utvecklas och transformeras.
Exempelvis skapade loop-diagrammet potential för meningsskapande diskussioner om kausala relationer och uppmuntrade till fördjupande frågor och reflektioner kring ämnets innehåll. En slutsats som dras är att visuella representationer är ett handlings-medierande verktyg som spelar stor roll för förmandet av de undervisning-lärande-praktiker som etableras i klassrummet.

Resultatet från de tre artiklarna diskuteras också i relation till två utmaningar: (i) hur förenklade visualiseringar av komplexa processer och strukturer kan möjliggöra för elever att utveckla en kvalificerad förståelse av dessa processer och strukturer och (ii) hur disciplinärt utvecklade visuella representationer, när de används i samhällskunskapsundervisningen, kan användas med ett annat mål än när de används inom disciplinen, där de utvecklades. Denna avhandling har både empiriska, teoretiska och praktiska bidrag och flera praktiska implikationer för undervisning och lärande i samhällskunskap har identifierats.
References


