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Article

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

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Keywords: visual representation, pricing, economics education, epistemic practice, affordance

- Choice of visual tool in teaching affects practices established and knowledge made available
- Two visual representations of price mediated different actions in the learning situation
- A causal loop diagram afforded more qualified actions than graphs
- In teaching, visual representations should be considered action-mediating tools

Purpose: This paper results from an intervention study focusing on the relationship between visual representation used in teaching about pricing in economics and teaching-learning practices established in the classroom, with a focus on the affordance offered through the representations used.

Method: Lessons were conducted with four upper secondary classes: two had lessons based on graphs and two on a causal loop diagram. Transcriptions of the lesson, including small group discussions, were analysed using a practice theory perspective, identifying actions and goals driving them. Results arising from the two representations were compared.

Findings: Different actions were mediated through the different representations. A causal loop diagram afforded more qualified actions, and more epistemic teaching-learning practices, than graphs.

Research limitations/implications: This study should be replicated with different subject contents /visual representations.

Practical implications: Choice of visual tools used in teaching will affect the practice established and thus the knowledge made available for students to experience.

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1 INTRODUCTION

Almost all teaching tries to grasp complex phenomena and help students develop a complex understanding and dynamic processes and structures. Traditionally, throughout history, teaching has often tried to simplify complexities, so that students can grasp the phenomenon focused upon, without reducing its complexity. This has often been done through the use of visual representations (Comenius, 2006/1682). In social science teaching in general and economics teaching in particular, many visual representations are used to clarify complexities and dynamic relations. Earlier research has shown that the composition of a visual representation can have a significant influence on 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; 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 a mediating function and thus the potential to afford different actions (Ewenstein & Whyte, 2009). Different visual representations may thus facilitate, or afford, different actions and thereby affect what is made possible for students to learn. In that sense, a visual representation has the potential to encourage, or mediate, more or less qualified understanding. Visual representations, as tools in a practice, can thus become important tools to develop knowledge. This paper results from an intervention study focusing on the relationship between visual representation used in teaching about pricing in economics and teaching-learning practices established in the classroom, with a focus on the affordance offered through the visual representations used. Results of the study show that there is a relation between the visual representation used in teaching and the teaching-learning practice established in the classroom. A causal loop diagram afforded more qualified actions and a more qualified understanding of the causal relationships in pricing than did supply/demand graphs.

2 BACKGROUND

2.1 Learning about pricing through visual representations

In economics teaching, supply/demand graphs (Figure 1) are frequently used as a visual tool to help students understand the complex relationships involved in pricing (Cohn, Cohn, Balch & Bradley, 2004; Reimann, 2004; Wheat, 2007a). However, previous research has shown that students often face problems when learning about pricing through such graphs. Problems pointed out are for instance the fact that dynamic and complex systems and processes are simplified and therefore also easily misunderstood (Cohn, Cohn, Balch & Bradley, 2001; Davies & Mangan, 2013) and that two-dimensional graphical representations are limited in terms of the complexity that can be visualised (Reingewertz, 2013; Ruiz Estrada, 2012). Also, labelling axes (Kourilsky, 1993; Strober & Cook, 1992; Zetland, Russo & Yavapokul, 2010), understanding key concepts (Ignell, Davies & Lundholm, 2017) and understanding how graphs are attuned to the 'real world' (Davies & Mangan, 2013; Strober & Cook, 1992) are pointed out as problematic

for students in relation to graphs in economics. In four experiments, Wheat (2007b) addressed this issue by investigating how an alternative visual representation of pricing, a causal loop diagram from system dynamics (Figure 2), could more efficiently help students understand the dynamics in pricing. The results showed that students preferred the casual loop diagram before 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.

Figure 1. Supply/demand graph illustrating pricing as a function of supply and demand.

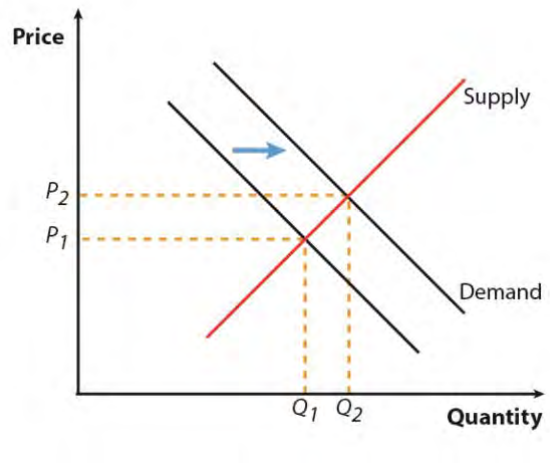
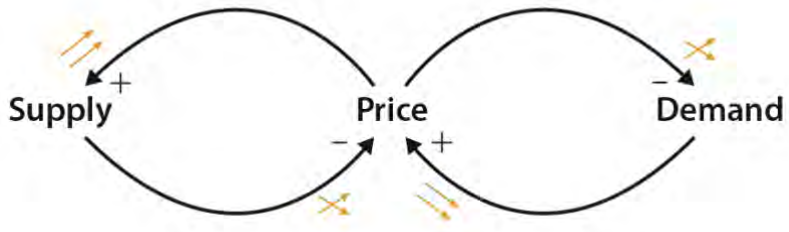


Figure 2. Causal loop diagram, illustrating pricing as a function of supply and demand, with + and – illustrating negative and positive correlation respectively and the red arrows illustrating how one variable changes when the other changes, i.e. same or different directions (adapted and developed from Wheat 2007a, p. 396).



Jägerskog (2020) extended Wheat's (2007b) research by using phenomenographic analysis to describe the results identified when a causal loop diagram was used to illustrate pricing as compared to graphs. The conclusions drawn by Wheat (2007b) were thus further unravelled by identifying students' conceptions of causality in pricing in relation to the two visual representations and by identifying what critical aspects of the phenomenon were discerned by the students through the two representations (the supply/demand graph and the causal loop

diagram). Students' conceptions of the relationships between supply, price and demand, as expressed in their written answers to open response questions before and after an intervention, were analysed. The results revealed that the critical aspects of causality in pricing, necessary for students to discern in order to develop the more qualified conceptions, were more easily discerned through a causal loop diagram than a supply/demand graph, resulting in more qualified conceptions of causation in pricing for students presented to the causal loop diagram.

The studies mentioned above focus on how the use of a certain visual representation is related to students' understanding of pricing. What they do not focus is how the choice of visual representation used 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 will take a practice theory perspective and investigate this matter further.

3. THEORETICAL FRAMEWORK: A PRACTICE THEORY PERSPECTIVE

A central idea in practice theory 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). In other words, participation in a practice is what makes learning possible (Radford, 2015, 2018). In that sense, learning could be considered "changing understanding in practice" (Lave, 1993, p 6). 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). Knowledge is thus considered not an individual property, but "a feature of groups, together with their material setup" (Schatzki, 2001, p. 21). '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, Arvola Orlander & Jedemark, 2004; Eriksson & Lindberg, 2016).

Within a practice theory perspective there are some central ideas to take into consideration when identifying practices. Four such ideas are of special interest for the analysis of this paper. First, *the tools that are used and developed in the practice mediate the actions and contribute to forming the practice* (Schatzki, 2001; Wertsch, 1998). Tools 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. Tools can for instance be artefacts, concepts, symbols and models (Wertsch, 1998). Models, being symbolic representations of a phenomenon or a system, are commonly used as tools for problem solving (Wertsch, 1998). A visual representation, such as a model of pricing as used in this study, could thus be understood as a kind of visual tool that mediate action. 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 (Fredlund, Airey & Linder, 2012), suggesting that different representations of the same phenomenon may afford different actions and provide access to different disciplinary-relevant aspects. Second, *people's actions (in this study both teachers' and students' actions) are 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 one can identify the goal of the action and thus identify the practice (Wertsch, 1998). Qualitatively different teaching-learning practices can develop during one lesson, although one practice is often dominating (Eriksson, Ståhle & Lindberg, 2011). Third, *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. Students can for instance carry out a task given by the teacher, but not necessarily with the goal of learning the intended, but with the goal of finishing the activity quickly or getting a good grade (Chaiklin, 1993). Such activities thus exemplify different practices as the actions are based on different goals. 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 (Carlgren, 2015; 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.

The term *teaching-learning practice* refers 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 students and the teacher want to accomplish, thus what is going on and why. Identifying and describing teaching-learning practices thus means identifying and describing the actions in the classroom, for instance as they are expressed in talk, and the goals driving them.

3.1 Epistemic practices

The results in this paper will also be discussed in light of 'epistemic practices'. *Epistemic practices*, a concept introduced by Knorr Cetina (1999, 2001, 2005, 2007), are 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). It could thus be argued that knowledge is not developed and transformed to the same extent 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 that are established - whether or not knowledge is developed and transformed (Eriksson & Linberg, 2016). This implies that teaching-learning actions within a practice can, depending on the enacted 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, as these activities open up for developing and transforming knowledge.

Ewenstein & Whyte (2009) suggest that visual representations are not peripheral to the epistemic work, but central to epistemic practices, as practitioners interact with those tools when they develop knowledge. Further, they suggest that many visual representations have the potential to 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. It is thus important to note that visual representations as tools in a practice can potentially, but not necessarily, facilitate the establishing of an epistemic practice.

4. AIM AND RESEARCH QUESTION

The aim of this study is 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 is on the relationship between teaching-learning practices established in the classroom and the visual representation as a tool, used in teaching. The research question therefore is: *What actions do 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 are thus established (during an introductory lesson and in small group discussions)?*

5. METHODS

5.1 Design of the study and participants

In a series of three lessons, taught over one and a half weeks, four upper secondary classes were introduced to economics and pricing. Two of the classes had lessons based on traditional supply/demand graphs (Figure 1) and two on a causal loop diagram (Figure 2). Teachers' and students' actions, as expressed though their talk, during the introductory lecture were analysed, as were students' actions during small group discussions following the introduction. Only material from the first two lessons were included in the analysis, as focus for the analysis was on teaching-learning practices established in relation to the introductory lecture of pricing and in the small group discussions.

The four classes included in the study were from two upper secondary schools in the Stockholm region, both having diverse catchment areas and similar student population. The student groups in both schools were thus divers and among the students there was a mix of backgrounds. All four classes took the course 'social science', including an introduction to economics. Social science is in Sweden a school subject studied by all students in both

compulsory (years 1-9) and upper secondary school (years 10-12). The school subject has a national curriculum, which means that regardless of what school students attend, they are given the same course. In all, ninety-four students, aged 16-18 years, participated in the study. All four classes included in the study were in their first or second year of upper secondary school. An additional three students (from three different classes) chose not to participate in the study.

Three teachers, all experienced social science teachers, were involved in the study. They all taught their own classes as part of their regular social studies teaching. Two teachers taught one class each (as they only taught social science to one class each this particular school year) and one teacher taught two classes. All three teachers, aged 36-49, were experienced teachers with several years' (12-22) experience of teaching social science in upper secondary school. They all have a similar teacher's degree for upper secondary school, specializing in social science and history. One teacher was male and two were female.

5.2 The visual representations used

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 only 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). The supply/demand graph is more traditionally used within the discipline and in teaching than the causal loop diagram. Important to note, the supply/demand graph, with its mathematical underpinning, illustrates more aspects of pricing than the causal relationships between supply, price and demand (such as price elasticity and calculating of price), whereas the causal loop diagram only illustrates this particular aspect of pricing. One could then argue that the two representations are rather different. However, they both illustrate the dynamic relationships in pricing. The causal loop diagram was disciplinary developed in order 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 equilibra" (Wheat, 2007a, p. 391). The purpose of the intervention in this study was to help students develop an understanding of dynamic causality in pricing, an aspect illustrated in both representations. Therefore, the two representations, although different in several ways, could be used to serve this purpose, as well as be compared in relation to this purpose.

5.3 The intervention

The first lesson was an introductory lecture on pricing and perfect competitive market, where the teacher explained the relationships between supply, price and demand while step by step

drawing one of the visual representations on the white board. During the lesson, students were invited to ask questions and comment on what the teacher presented. The second lesson started with a re-cap of the introductory lesson, followed by small group discussions and a follow-up discussion in class. All classes, independent of visual representation used, shared the same lesson plan (see Table 1) and the same introductory examples were used in all classes. Both lectures and small group discussions were filmed and transcribed. Students also answered open response questions before and after the intervention in order to enable an analysis of how students' conceptions of price develop in relation to two different visual representations. Results from this analysis have been reported elsewhere (Jägerskog, 2020).

In the small group discussions, groups of three to five students were given a sheet of paper with two questions spelled out (Q1 and Q2, see Appendix), together with the visual representation used in teaching (Figure 1 or Figure 2) and an explicit request to use the visual representation as a help in discussing the questions. One question focused on price on a new, and demanded, film service (Q1) and the other on effects on milk prices if there was a change in supply (Q2). 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 10 minutes. The use and formulation of the questions were confirmed through a pilot study with 30 students not included in the main study.

Table 1. Content focused upon and examples used in research lessons based on supply/demand graphs and a causal loop diagram respectively. Differences in italics. (Adapted from Jägerskog, 2020)

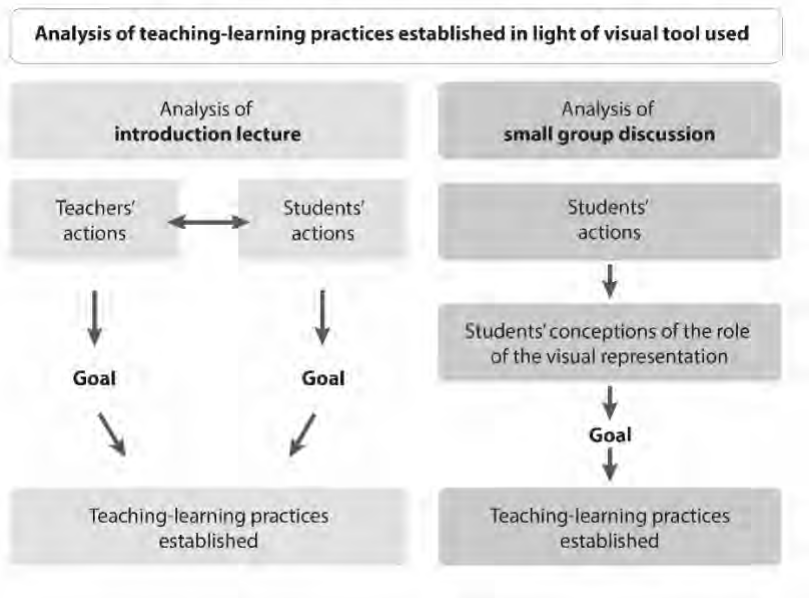
Research lesson	Teaching using supply/demand graphs	Teaching using causal loop diagram
Lesson 1: Content	Introduction to pricing and perfect competitive market *by drawing three supply/demand graphs* on the white board (showing (i) supply logic, (ii) demand logic and (iii) reciprocal relationship between demand and supply resulting in price)	Introduction to pricing and perfect competitive market *by drawing the causal loop diagram* on the white board
Lesson 1: Examples used	Tomatoes and buns as introductory examples	Tomatoes and buns as introductory examples
Lesson 2: Content	Re-cap of the introduction to pricing through *drawing the graphs* on the white board. Small group discussions followed up by discussion in class.	Re-cap of the introduction to pricing through *drawing the causal loop diagram* on the white board. Small group discussions followed up by discussion in class.
Lesson 2: Examples used	Price on milk and streaming service for films (group discussion questions)	Price on milk and streaming service for films (group discussion questions)

5.4 Data analysis

Two different materials were analysed: (1) transcriptions of the introductory lecture (including both teachers' talk and students' questions and comments), and (2) transcriptions of the small group discussions (21 groups in total). Transcriptions from the introductory lecture (lesson 1) and from the recap of this introduction (beginning of lesson 2) were analysed qualitatively (see Figure 3). Teachers' ways of talking about pricing, as well as students' questions and comments, were analysed in order to identify actions and goals driving them. Actions were thus analysed as they were expressed through talk. This was done by reading the transcriptions in light of two questions: what the teachers/students do (for instance a student asking why a detail in the illustration looks as it does) and what s/he tries to accomplish through this action (clarify the logics of the representation). Teachers' and students' actions were also related to each other in order to investigate if some teacher actions encouraged certain student actions. This was done in terms of analysing what kind of teacher action preceded each student action. A quantitative analysis was applied for this purpose, in terms of counting student utterances in relation to each teacher action. Each unit counted was thus one utterance. 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.

Transcriptions from small group discussions were analysed in order to identify students' actions. Students' conceptions of the role of the visual tool used were also identified and related to their 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. Only parts of the discussions where the illustration was used were included in the analysis.

Figure 3. Schematic description of qualitative analysis of introductory lecture and small group discussions.



6 RESULTS

The results are presented in three sections: an analysis of *the introductory lecture*, where teachers' and students' actions are identified and thus what teaching-learning practices are established (section 6.1), an analysis of *small group discussions,* where students' actions, as well as their conceptions of the role of the visual representation used, are identified and thus what teaching-learning practices are established (section 6.2) and *a synthesis of the results* from both lectures and small groups discussions, where the different teaching-learning practices established are related to each other (section 6.3).

6.1 Analysis of introductory lecture

6.1.1 Teachers' and students' actions

Three different actions were identified among the teachers and could be defined in terms of (1) describing logics, (2) explaining cause and effect and (3) elaborating on complex relationships (i-iii in Table 2). In actions describing logics, focus was mainly given to describing the logics behind the visual representations, describing curves and calculating potential prices. In actions explaining cause and effect*,* teachers focused on the unidirectional relationship between two of the variables (the effect of price on demand/supply or the effect of demand/supply on price) and explained the characteristics of that particular causation. In actions elaborating on complex relationships, the bigger picture of how supply, price and demand interactively affect each other was explained.

Five different kinds of actions among the students were identified during the introductory lecture (A-E in Table 2). First, there were actions asking for a *clarification of the visual representation* (A), characterised by questions about the illustration used, as well as statements of not understanding the illustration presented. Second, there were actions asking for a *clarification of a causation* (B), where students either asked questions about the causation being discussed, or wrongly guessed how the relationship between two variables in pricing relate to each other. Third, some actions were *statements about/comments on a causation* (C), where students expressed an understanding for the characteristics of a certain causation in pricing through either reflecting on it or correctly explained its characteristics. Fourth, in some cases the actions were characterised by *problematising/exemplifying a causation with another good or condition* (D). A student could for instance introduce special offers in grocery stores in order to exemplify the relationship between price and demand, or problematise the relationship between price and demand by introducing the housing market. Finally, there were actions *reflecting about relationships between several variables involved in pricing* (E), where students elaborated on price being more complex than only a causation between two variables, thus including both supply, demand and price. Actions (A) and (E) are distinctly different from other actions identified. Actions (B)-(D) are more similar as they all are driven by the goal to understand causation in terms of unidirectional relationships in pricing. However, they differ in terms of what the student does in relation to the causation (clarifying, commenting, problematising), where the latter two are more elaborate than the former. Differentiating

those three actions was important for identifying teaching-learning practices in relation to the two visual representations used, as will be seen in section 6.1.3 below.

6.1.2 Relation between teacher's and students' actions during the introductory lecture

The analysis identified a clear relation between the teacher's and students' actions during the introductory lecture. As illustrated in Table 2, each of the three teacher actions (describe logics, explain cause and effect and elaborate on complex relations) were related to certain kinds of actions among the students. The relation between the teacher's and the students' actions, as well as the goals driving those actions, will be explained further below and exemplified with excerpts from the classroom discussions held during the introductory lecture.

When the teachers described logics, focus was on curves and potential prices and much of the teachers' talk was focusing on explaining the representation. The teachers often talked about the relationships between supply, price and demand in terms of how the variables 'meet', 'are even', 'are crossed', 'are put together', etc. A major part of students' actions related to this teacher action, in terms of their response to the teacher's introduction of pricing, were characterised by asking for *clarification of the visual representation* as such. The goal driving both teacher's and students' actions seemed to be to describe (teacher)/understand (students) the visual representation and the logics behind it, thus understand the inner workings and function of a graph. Excerpt [1] below exemplifies this.

[1]

Teacher: If more actors want to enter the market, the curve will move. More buns will be produced and then this curve (points to the supply curve) will kind of move downwards. What will happen to price now?

Student: But why does it go that way? Shouldn't it move the other way, above the grey dot?

Teacher: This is the price (points to equilibrium).

Student: But if this is more to the right, does this not mean that there is a bigger supply, I mean more…?

Teacher: No, think about it this way, if the supply curve moves, we need to draw a new curve.

Table 2. Summary of the relations between teacher's and students' actions during the introductory lecture and the goals driving them.

Teacher's actions	(i) Describe logics	(ii) Explain cause & effect	(iii) Elaborate on complex relationships
Students' actions (verbal responses)	(A) Clarification of the illustration, often in terms of questions asked	(B) Clarification of a causation, often in terms of questions asked (C) Make a statement about/comment on the character of a causation (D) Problematise/ exemplify a causation with another good or condition	(E) Reflect about relationships between several variables in pricing
Goal	Describe (teacher) /understand (student) the visual representation and the logics behind it	Explain (teacher) /understand (student) unidirectional relationships in pricing	Elaborate on (teacher) /understand and reflect on (student) the dynamically interrelated relationships in pricing

In this example, the teacher explained an increased supply in terms of a moving curve and the student tried to understand the logics behind the moving curve.

When the teachers *explained pricing as cause and effect*, the explanations of pricing focused on one single causation at the time, such as the effect of price on demand, and on the characteristics of this causation. The teachers often expressed the relationship between the variables in terms of 'affect', 'if x, then y', 'the more/less of x, the less/more of y', etc. Three different student actions were identified related to this type of teacher action, all dealing with how one variable in pricing relates to another: *clarification of a causation*, often in terms of questions, as the students did not grasp the logics in the causation explained by the teacher (see excerpt [2] below), *making a statement about or comment on the character of a causation*, expressing an understanding of causations (se excerpt [3] below), and *problematising or exemplifying a causation with another good or condition.* The two latter categories required a more elaborate understanding of the causations, for instance as the teacher's examples were contrasted with other goods or conditions. The goal driving these three actions, as well as the teacher's action focusing on cause and effect, was to explain (teacher)/understand (student) causation in pricing.

[2]

Teacher: If you want to make money, then the higher price – the more you want to offer. Do you understand?

Student: But if I think as a seller, it doesn't work.

Teacher: But do you understand the logics: If you want to make money, then the higher price – the more you want to offer.

Student: No, I don't.

Teacher: If I sell strawberries, I'd rather sell 10 kilos for 100 sek than 1 kilo for 25, wouldn't I?

Student: So they pay a lot and get a lot?

Teacher: No, just think about yourself as a seller.

Student: I think this really gets reversed in our brains. It gets wrong.

[3]

Teacher: So, price affects demand. Are you with me? In what way do you think that demand affects price?

Student A: If the demand is big, prices will increase.

Teacher: Exactly, when demand increases, prices will also increase. Why so?

Student A: Because people will pay, so then the producers could as well make money on it.

Teacher: Yes, but don't involve the producers and the supply just yet - a certain amount of goods is offered, but many people want it.

Student B: If many want it, then there will be competition about it and the price will increase.

In excerpt [2], the teacher introduced the relationship between price and demand, but the students struggled to understand this causation, which is shown through the student expressing confusion and asking for clarification. In excerpt [3], the teacher introduced the causation between demand and price, which the students made statements about and commented on, showing that they understood the characteristics of the causation.

When the teachers *elaborated on complex relationships*, focus was on the dynamic interrelations between supply, price and demand. Teachers' talk about the relationships were often expressed in terms of 'affect each other', 'connection between', 'interact', 'are linked together', etc. Students' actions were mainly characterised by *understanding/reflecting on relationships between several variables in pricing,* which was also the goal driving both teacher's and students' actions. This is exemplified in excerpt [4] below.

[4]

Teacher: So, a price is set through supply and demand and this is what we are looking at – how those different variables relate to each other. So if we begin with the seller – how would you think if you were a seller? How much do I want to sell and to what price?

Student: Well I think… I think about flea markets, because if you're at a flea market you need to think about what it is worth, how much you think people will be willing to pay for it.

Teacher: Yes, because you really want to get rid of it.

Student: And the price you sell it for all depends on supply and demand. If for instance the supply is quite low, and many want it, then… Because if something is really popular, it gets quite expensive, and because you don't have much of it, but you know that people want it, then you use that situation and sell it to a high price.

In this excerpt, the teacher introduced the idea of pricing as complex relationships between supply, price and demand and the student responded by reflecting on a flea market and how prices there were set through the interplay between supply and demand.

6.1.3 Teaching-learning practices established in the graph-based and the causal loop diagram-based lectures

Two different teaching-learning practices were established in the graph-based lecture and the diagram-based lecture respectively, as teachers' and students' actions, mediated through the different visual tools used, were different in the two lectures. Accordingly, the goal and the price related knowledge made available for the students to experience also differed between the two lectures. In the graph-based lecture, a *describe logics – explain cause and effect practice* was established. Although all three teacher actions were identified in the graph-based lecture, there was a clear dominance of actions focusing on describing logics and explaining pricing as cause and effect. Students' actions were mainly characterised by clarification of the illustration (A) and clarification of causation (B) (see Table 3). The predominant goal was to explain (teachers)/understand (students) the logics behind the visual representation and the unidirectional relationships in pricing, which was also the price related knowledge made available in this teaching-learning practice.

In the causal loop diagram-based lecture, a rather different pattern was identified, as an *explain cause and effect – elaborate on complex relationships practice* was established. Teachers' actions were dominated by explaining cause and effect and elaborating on complex relationships. Students' actions were characterised by commenting on the character of the causation (C), problematising/exemplifying with another good or condition (D) and reflecting about relationships between several variables in pricing (E) (see Table 4). The goal driving both teachers' and students' actions was to understand, reflect about and elaborate on both unidirectional and dynamically interrelated relationships in pricing and the learning facilitated in this teaching-learning practice was thus more qualified than in the former practice.

In summary, there was a difference in what teaching-learning practices were established in the lecture in relation to what visual representation of pricing was used in the lecture: the teaching-learning practice established in the causal loop diagram-based lecture seemed to mediate and facilitate a more qualified conception of pricing than did the teaching-learning practice established in the graph-based lecture.

Table 3. A describe logics – explain cause and effect practice established in the graph-based lecture: distribution of students' actions in relation to teacher's actions. Each unit is one student utterance.

	Teacher's actions in graph-based lectures			
Students' actions	Logics	Cause & effect	Complex rel.	Total
A. Clarification of the illustration	13 (65%)	2 (7,1%)	1 (25%)	16 30,8%
B. Clarification of a causation	3 (15%)	18 (64,3%)	0 (0%)	21 40,4%
C. Make a statement about/comment on the character of a causation	4 (20%)	7 (25%)	1 (25%)	12 23,1%
D. Problematise/exemplify with other good or condition	0 (0%)	0 (0%)	0 (0%)	0 0%
E. Reflect about relationships between several variables in pricing	0 (0%)	1 (3,6%)	2 (50%)	3 5,7%
Total	20 (38,5%)	28 (53,8%)	4 (7,7%)	52 100%

Table 4. An explain cause and effect – elaborate on complex relationships practice established in the causal loop diagram-based lecture: distribution of students' actions in relation to teacher's actions. Each unit is one student utterance.

	Teacher's actions in causal loop diagram-based lectures			
Students' actions	Logics	Cause & effect	Complex rel.	Total
A. Clarification of the illustration	0 (0%)	3 (8,8%)	0 (0%)	3 (7,3%)
B. Clarification of a causation	0 (0%)	4 (11,8%)	1 (14,3%)	5 (12,2%)
C. Make a statement about/comment on the character of a causation	0 (0%)	20 (58,8%)	1 (14,3%)	21 (51,2%)
D. Problematise/exemplify with other good or condition	0 (0%)	7 (20,6%)	1 (14,3%)	8 (19,5%)
E. Reflect about relationships between several variables in pricing	0 (0%)	0 (0%)	4 (57,1%)	4 (9,8%)
Total	0 (0%)	34 (82,9%)	7 (17,1%)	41 (100%)

6.2 Analysis of small group discussions

6.2.1 Students' actions and conception of the role of the visual tool

Four categories of student actions were identified in the 21 small group discussions: (1) state that one does not understand the illustration and/or how it is used, (2) try to decode and understand the different parts of the visual representation and how they are related, (3) suggest and confirm misleading logics of pricing and (4) discuss the logics of pricing with support from the representation (A-D in Table 5). In addition, three conceptions of the role of the visual tool were identified through the actions: the visual tool as (1) an illogical illustration, (2) an objective for the discussion and (3) a means for discussing pricing (i-iii in Table 5).

6.2.2 Relation between students' actions during small group discussions and their conceptions of the role of the visual tool

As illustrated in Table 5, the analysis identified a relation between students' conceptions of the role of the visual tool and their actions during small group discussions. This relation, as well as the goals driving the actions, will be explained further below and exemplified with excerpts.

Table 5. Summary of the relations between students' actions during the small group discussions and students' conceptions of the role of the visual representation (the tool), as well as the goals driving the actions.

Students' conception of the visual tool as…	(i) An illogical illustration	(ii) An objective for the discussion	(iii) A means for discussing pricing
Students' actions	(A) State that one does not understand the illustration or how it should be used Express frustration concerning the illustration being illogical	(B) Try to decode and understand the different parts of the illustration and how the parts relate to each other	(C) Suggest and confirm misleading logics of how pricing works, with support of the illustration (D) Discuss the logics of the relationships involved in pricing, with support of the illustration
Goal	Understand the function of the visual representation	Decode and understand the illustration	Understand pricing

First, when the visual representation was considered *an illogical illustration*, the actions were characterised by students stating that they did not understand the illustration, that they did not know how or why to use it, or that they considered the illustration illogical. The goal driving these actions was to understand the function of the visual representation and the point of using it at all. This is exemplified in excerpt [5] below.

[5, discussion based on a supply/demand graph]

Student A: Say something about the diagram.

Student B: Okay, this thing with equilibrium. I think that… eh… because Netflix costs… eh… well I don't know.

Student C: Let's see. Quantity, equilibrium (points to the x-axis and the equilibrium)… eh… I really don't know.

Student B: I mean this… It's not like we can use these curves… I don't understand a thing of this crap!

Student C: Nor do I. Or I do, but I don't know what equilibrium is.

Student B: I know what it is, but I don't know what it has to do with this.

Student A: I don't know what it is and I don't know how to use this thing.

In this excerpt, the students expressed frustration about not understanding the visual representations and they did not see the point in using it.

Second, in group discussions where the visual representation was considered *an objective for the discussion* itself, the actions were characterised by trying to understand the illustration and decode the different parts, as well as how the different parts should be understood in relation to each other, which could be understood as the goal driving these actions. The discussions were often characterised by the students trying to solve a 'school problem'. Excerpt [6] below exemplifies this.

[6, discussion based on a supply/demand graph]

Student A: Okay, so if we pretend that this is 1 (points to Q1 on the x-axis) and then this is linked to this point (points to P1 on the y-axis), and this is the price for one (points to the equilibrium), let's say 10 sek for one.

Student B: But this graph here (points to the demand curve) is how many people want… I mean…

Student A: Yeah, and this is the companies (points to the supply curve). Or is it? Do you think this is the companies?

Student B: Yes, because the more people there are… I mean this is how much there is of something (points to the x-axis) and then it gets less and less (points along the x-axis towards where the axes intersect). And this is where it is cheap and then it gets more and more (points along the y-axix). And then more people are willing to pay little (points to the lower end of the demand curve).

In the excerpt above the students tried to figure out the logics of the graph itself. Although the discussion revolved around pricing, decoding the visual representation was in the foreground.

Finally, when the visual representation was understood as *a means for discussing pricing*, the discussions dealt with pricing and the representation was used to support this discussion. However, two different actions were identified in relation to this conception of the visual tool. First, in some cases the visual tool seemed to afford a confirmation of misleading logics concerning the relationships in pricing. Students were often rather assertive about their conclusions and other members in the group affirmed their ideas, which led to the whole group

drawing mistaken conclusions about pricing and economics. The goal driving this action seemed to be to underpin existing ideas of how pricing works and the visual tool therefore did not afford the students to develop a more qualified understanding of pricing and economics. Excerpt [7] below exemplifies this kind of action. Second, in some cases when the visual representation was understood as a means for discussing pricing, the illustration mediated drawing of correct and qualified conclusion. Those actions were characterised by students discussing the logics of the relationships involved in pricing, with support of the illustration. The goal was to understand how pricing works in terms of the dynamic relationships between price, supply and demand. Excerpt [8] below exemplifies this.

> [7, discussion based on a supply/demand graph]
>
> Student A: Okay, supply curve… (points to the supply curve)
>
> Student B: I don't even know what that word means.
>
> Student A: Don't you? Supply is how much there is of something (points to the supply curve). And the fewer there are of something, the lower the price (points to the lower left of the supply curve) and the more there is of something, the higher the price will get (points to the upper right corner of the supply curve).
>
> Student C: Yeah, that's right.

> [8, discussion based on causal loop diagram]
>
> Student A: But if there is an increase in demand (points to the arrow between demand and price), prices will increase.
>
> Student B: And there will be a high demand, because they are going to offer all movies
>
> Student A: Yeah, demand will be high (points to 'demand' in the diagram), many want this film service, so the price will be high.
>
> Student C: And then the supply… that will grow (points to the arrow between price and supply). Because when demand is high, price will increase and then supply will also increase.
>
> Student B: But if there is another company who does the same thing, but to a lower price, then…
>
> Student C: Yeah, then the price would go down (points to the arrow between supply and price).

In excerpt [7] student A used the graph to explain the relationship between supply and price. This example illustrates how the graph afforded a confirmation of an illogical way of reasoning about pricing. Excerpt [8] exemplifies a group discussion where the discussion revolved around pricing and the representation mediated a logical reasoning about pricing.

6.2.2 Teaching-learning practices established in the graph-based and the causal loop diagram-based small groups discussions

Two different teaching-learning practices were established in small group discussions when a graph and a causal loop diagram was used respectively, thus the visual tools mediated very different actions. In the graph-based group discussions, a *not understand - decode - confirm practice* was established. Although all three conceptions of the role of the visual tool (as an

illogical illustration, as an objective for the discussion and a means for discussing pricing) were found in the graph-based group discussions (see Table 6), with one exception (see group 8 in Table 6), only actions A-C (state that one does not understand the illustration, try to decode and understand the illustration, suggest and confirm misleading logics) were exemplified in these discussions. This means that there were hardly any examples where the graph mediated a logical reasoning about pricing (action D in Table 6). The understanding of pricing facilitated in the graph-based group discussions was thus mainly decoding the different parts of the visual tool used and a misleading understanding of how pricing works.

The pattern was very different in the small group discussions based on a causal loop diagram (see Table 7), where a *discuss pricing practice* was established. All discussions in those small groups revealed an understanding of the visual representation as a means for discussing pricing and the causal loop diagram mediated a logical reasoning and helped the students to draw correct and qualified conclusions about pricing. At one occasion (see group 6 in Table 7) a student used the visual tool to draw a misleading conclusion, but was corrected by another member of the group on the basis of the illustration. The understanding of pricing facilitated in these groups was thus how pricing works in terms of the dynamic relationships between price, supply and demand, which was also the goal of the actions.

In summary, there seems to be a clear difference in the teaching-learning practices established in small group discussions depending on what visual representation of pricing was being used. The causal loop diagram afforded students to use the illustration as a means for discussing pricing and the actions were clearly more qualified than the actions in the graph-based small group discussions.

Table 6. A not understand - decode - confirm practice established in the graph-based small group discussions: distribution of students' actions in relation to their conceptions of the role of the visual representation. Results for graph-based small group discussions only.

Conception of the role of the visual representation as…		Illogical illustration	Objective for discussion	Means for discussing pricing	
Actions	No use of the vis. repr. in the discussions	A. State that one does not understand the illustration	B. Try to decode and understand the illustration	C. Suggest and confirm misleading logics	D. Discuss the logics of pricing with support of the illustration
Group 1		X		X	
Group 2			X	X	
Group 3		X			
Group 4				X	
Group 5		X			
Group 6			X		
Group 7	X				
Group 8			X	X	X
Group 9	X				
Group 10	X				
Group 11		X			

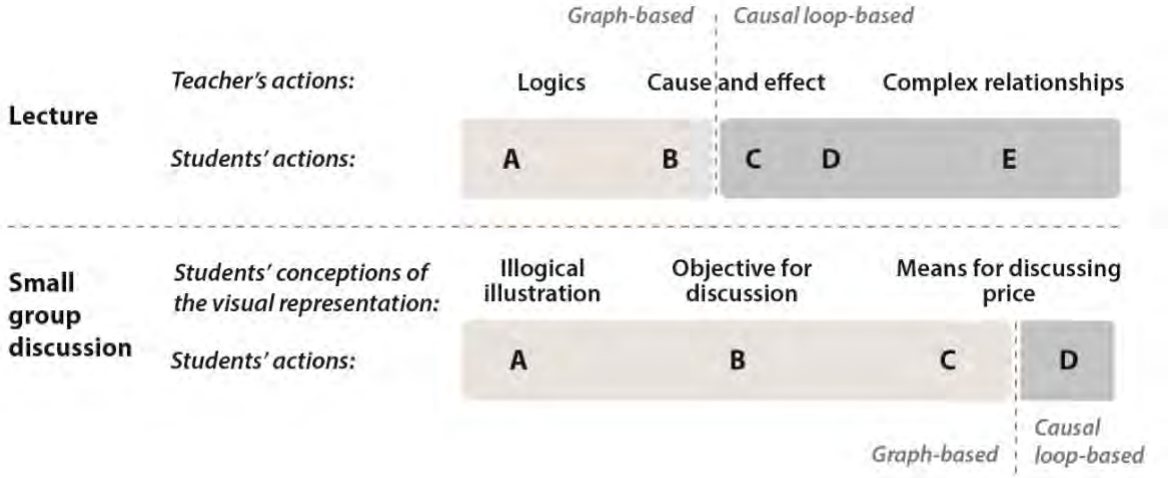
Table 7. A discuss pricing practice established in the causal loop diagram-based small group discussions: distribution of students' actions in relation to their conception of the role of the visual representation. Results for causal loop diagram-based small group discussions only.

Conception of the role of the visual representation as…		Illogical illustration	Objective for discussion	Means for discussing pricing	
Actions	No use of the vis. repr. in the discussions	A. State that one does not understand the illustration	B. Try to decode and understand the illustration	C. Suggest and confirm misleading logics	D. Discuss the logics of pricing with support of the illustration
Group 1	X				
Group 2	X				
Group 3					X
Group 4					X
Group 5					X
Group 6				X	X
Group 7					X
Group 8					X
Group 9					X
Group 10					X

6.3 Synthesis of the results from lectures and small group discussions

Analyses reveal that there is a relation between the visual representation used in teaching and the teaching-learning practice established in the classroom, thus what actions the different visual tools mediated. The pattern was similar for both lecture and small group discussions (see Figure 4): a causal loop diagram mediated more qualified actions and thus a more qualified understanding of the causal relationships in pricing than graphs. This was seen in terms of teachers' actions opening up for a more complex understanding of pricing when a causal loop diagram was used, as well as students' actions and conception of the role of the visual representation being more elaborated and qualified when based on a causal loop diagram than on graphs. Teaching-learning practices established when the teaching was based on graphs were thus a *describe logics – explain cause and effect practice* (introductory lecture) and a *not understand - decode - confirm practice* (small group discussions), whereas teaching-learning practices established when teaching was based on a causal loop diagram was *explain cause and effect – elaborate on complex relationships practice* (introductory lecture) and *discuss pricing practice* (small group discussions). In the latter two teaching-learning practices, more qualified and complexity-oriented teacher actions, student actions and conceptions of the role of the visual representations were mediated.

Figure 4. Summary of dominating actions (teachers' and students'), and conceptions of the role of visual representation, in the lecture and small group discussions when based on graphs and causal loop diagram respectively.



7 DISCUSSION

This discussion comments on two ways in which results from this study contribute to earlier research: in relation to economics teaching and learning specifically and in relation to teaching and learning through visual representations in general.

First, a couple of previous studies have investigated students' understanding of pricing when two different visual representations were used in teaching. These studies concluded that for novice learners in economics, a causal loop diagram seems to facilitate a more qualified understanding of pricing than the graph (Jägerskog, 2020; Wheat, 2007b). The present study contributes with using a practice theory perspective in the attempt to unravel this conclusion further and to deepen the understanding of why the causal loop diagram seems to facilitate a more qualified understanding of pricing among novice learners. Focusing on actions in the classroom, rather than merely on pre- and post-tests identifying students' understanding of the phenomenon before and after the intervention, opens up for another kind of discussion concerning the use of different visual representations of pricing in economics teaching and learning. The concept of *epistemic practice* (Knorr Cetina, 1999, 2001, 2005, 2007) turns out to be helpful in this aspect. Results suggest that the teaching-learning practices established in 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. Accordingly, an epistemic practice was more encouraged in the loop diagram-based classrooms than the graph-based classrooms, both in terms of the introductory lecture and the small group discussions. This became especially clear in the group discussions. Seen from the outside,

students seemed to be doing the same thing in all small group discussions: discuss pricing with the help of a visual representation. However, when the material was analysed in terms of actions and goals driving them, it was revealed that students in the different groups 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. In the small group discussions, the causal loop diagram mainly afforded discussions concerning the causal relationships in pricing, thus functioned as a means for developing an understanding of pricing 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 seems as if 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 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.

Second, this study contributes with an example of how a practice theory perspective can contribute to the discussion of the role of a visual representation in teaching and learning. The visual representation as an action mediating tool, playing a central role in forming the teaching-learning practice established, and thereby the learning facilitated, becomes 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 actions the visual tools mediate, thus what actions and teaching-learning practices are being established through the use of them. In that sense the main results of this study is not merely that a causal loop diagram seems to afford a more epistemic practise 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.

7.1 Reflections on methodology

Three teachers were involved in the study, teaching one or two classes each. It cannot be ruled out that the results of the study were affected by differences between the teachers involved. For instance, one could argue that the results could be due to the teachers having different understanding of the content. To minimize the risk of the individual teacher being the reason for the differences between the groups, the teachers involved were all experienced social science teachers, with a similar background and education. Also, the lessons included in the study were carefully planned and the teachers thus had a detailed lesson plan (including both the structure of the lessons as well as examples to use) to follow in order for the lessons to become as similar as possible in the four classes. It is yet possible that the difference in results between the different groups could partly be due to the three teachers dealing with the visual representations as well as the students' questions differently. However, the differences in

teaching-learning practices established, in relation to visual tool used, were shown not only in the study in general, but also for the teacher who taught two different classes (one with each visual representation). This indicates that the differences identified are not merely to be explained by individual differences among the teachers, but need to be related to the actions invited to through the mediating tools, a conclusion also supported by the theoretical framework applied. That said, it cannot be ruled out that teaching two classes based on two different visual representations, as was the case for one of the teachers, may have had an effect on the teaching. To minimize this risk, this teacher first held the lessons based on the conventional graph, which s/he traditionally used, and then held the lessons based on the causal loop diagram, which was new to him/her. By doing so, the risk that the new way of illustrating pricing (through the causal loop diagram) would have an effect on how the teacher talked about pricing during the graph-based lesson, was minimized.

Students' preunderstanding of pricing was measured before the intervention to make sure that the groups did not differ significantly in terms of their understanding of the content, as this could have affected the results. Also, all classes had their intervention during the same time period and were thus subject to similar current news between the lessons (although questions concerning pricing were not particularly highlighted in news or media during this period). Two similar schools, in terms of catchment area and students' divers background, were chosen in order to minimize the risk of differences between the school affecting the results. Also, classes were chosen so that no classes taking extra mathematics were involved in the study, as this may have affected their understanding of the graph.

The fact that the two visual representations, although both illustrating the relation between supply, price and demand, are fundamentally different - the graph being a mathematical structure and the loop diagram illustrating the structures in the relationships - could further explain that different actions are mediated through the different visual tools. However, important to note, the results should not be seen as a deterministic connection between visual representation used and teaching-learning practice established. Instead, the results should be considered an example of the relationship between visual representations used as a tool mediating actions and the teaching-learning practices established, and evidence for the risk of graphs contributing to a less epistemic practice than the causal loop diagram.

7.2 Future studies and concluding remarks

Future studies should replicate the findings presented in this paper, preferably with a design where all involved teachers teach two classes each, so that some of the methodological aspects discussed above could be ruled out. Also, future studies should replicate this study with other subject content, thus with other visual representations.

The results from this study imply the need for an active choice of visual representation used in economics teaching as well as in teaching in general. Results also imply that investigating how teaching-learning practices, and thereby learning, are related to the use of visual representations, has the potential to offer an important complement to aspects on teaching and learning through visual representations.

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APPENDIX

Q1. 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 answers.

Q2. For many years, one company provided most of the supply of milk sold in Swedish grocery stores. In recent years, more and more companies have been established on the milk market. What will happen to the milk market and milk prices of more companies are established on the market and why? Reason and give arguments for your answers.

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