ABSTRACT
Enterprise education is a policy-driven, cross-curricular phenomenon on many Western countries’ educational agendas. The expectation is that it will be implemented in different school subjects, but bridging enterprise education and different school subjects has proven to be a challenge. This article explores whether and how open-ended investigations in science education in secondary schools can be viewed as a form of enterprise education. We identify several points of contact, illuminating the premises on which enterprise education can be integrated into science education. Thus, the results contribute to the under-researched field of bridging enterprise education with school subjects in secondary education.

KEYWORDS
Enterprise education; entrepreneurship education; science education; secondary school; open-ended investigations

Introduction
Both national and international education policies stress the importance of enterprise education, one of many cross-curricular phenomena in basic education (Dal, Elo, Leffler, Svedberg, & Westerberg, 2016; Haara, Jenssen, Fossoy, & Røe Ødegård, 2016). Simultaneously, Western educational systems are based on subject division, and different school subjects pursue different paths in developing teaching methods and content. In an educational system structured on subject division, cross-curricular themes, such as enterprise education, are supposed to be integrated into subject teaching (Elo, 2015). According to a research review by Haara et al. (2016), the connections between enterprise education and individual school subjects are a rather under-studied area, although these connections have been examined somewhat. Examples include music (Garnett, 2013; Hietanen, 2015), mathematics (Palmér & Johannson, 2018), visual arts (Elo & Kaihovirta, 2017) and crafts (Elo, 2016b; Rönkkö & Lepistö, 2016). As a phenomenon, enterprise education is under-researched, particularly at the primary and secondary levels (Hietanen & Järvi, 2015; Johansen & Schanke, 2013; Moberg, 2014).

Finding a balance between subject teaching and cross-curricular goals can be a challenge for teachers (Elo, 2015; Palmér & Johansson, 2018). Ideally, subject and cross-curricular goals are mutually supportive, but in a worst-case scenario, they are in conflict. In this article, we attempt to bridge enterprise education and the teaching...
method of open-ended investigations within science education. Bridging these two phenomena can enhance understanding of how teachers within a subject-focussed educational structure can focus on a cross-curricular phenomenon while simultaneously developing their subject teaching. Thus, striving for cross-curricular goals would not come at the expense of subject teaching, but rather through it.

This article’s objective is to explore how enterprise education can be understood in the context of open-ended investigations in science education at the secondary level. Our attempt to bridge the phenomena has its starting point in the concept of Didaktik (Hopmann, 2007), where the “what?”, “why?” and “how?” questions (content, aim and method) are often presented as core questions (Arfwedsson & Arfwedsson, 1991; Uljens, 1997). Our focus is on the “why?” and “how?” questions, as we target on exploring connections in two key areas: the view of the learning process (how) and key goals (why). By focusing on examining similarities in these fundamental areas between the two phenomena, the article contributes to the understanding of the connections between enterprise education and specific school subjects at the secondary level, a weakly researched field. The results should prove helpful for teachers – as well as teacher education, curriculum development and education research – in facing the challenge of combining enterprise education with science education. The article is structured in five sections. After the introduction, Section 2 outlines the phenomenon of enterprise education, and Section 3 examines open-ended investigations. Section 4, elaborates on the connections between the two phenomena regarding the learning process (how) and key goals (why). In Section 5, the concluding discussion focuses on highlights from the findings and their implications.

**Enterprise in education**

Education and economic policies are related closely to each other in contemporary society, as education increasingly is viewed as a means for a country or region to respond to global competition (Mahieu, 2006). Therefore, views regarding education’s ideals, values, goals and practices have been evolving with the times (Lund, 2010; Mahieu, 2006; Riese, 2010; Säljö, 2010). On a policy level, education’s focus gradually has shifted toward emphasising students’ generic competency levels, i.e., skills that enable individuals to cope and succeed in a changing world, regardless of context (e.g., European Parliament and Council, 2006; Finnish National Board of Education, 2016; Uljens & Rajakaltio, 2015).

The Organisation for Economic Cooperation and Development (OECD), among other groups, has criticised schools and education systems for their reliance on a teacher- and subject-centred approach to education, emphasising reproduction of information, knowledge dissemination, normativity, conformity and tradition (Mahieu, 2006). This criticism targets both the approach to the learning process, as well as education’s goals. In an ever-changing world, this emphasis is not viewed as conducive to developing the kind of knowledge and skills needed in contemporary and future society. In line with this reasoning, and inspired by the OECD, many Western countries have introduced entrepreneurship education or enterprise education into basic education (Dal et al., 2016). In this context, enterprise education has been presented as an answer to many contemporary demands and challenges, often portrayed as the positive opposite of “traditional” teaching (Hägg & Peltonen, 2011).
Enterprise education aims to develop skills, attitudes, abilities, attributes and competencies that are useful in contemporary and future society regardless of context (Dal et al., 2016; Jones & Iredale, 2010; Leffler, Svedberg, & Botha, 2010; Pepin, 2012). Examples of goals for enterprise education include developing student proactivity, problem-solving skills, creativity and a sense of initiative. Therefore, enterprise education is not connected necessarily to the business sector or economy (Hoppe, 2016; Jones & Iredale, 2010). Conversely, entrepreneurship education aims to develop skills and knowledge that are related directly to promoting small-business ownership (Dal et al., 2016; European Commission, 2004; Jones & Iredale, 2010; Leffler et al., 2010; Quality Assurance Agency for Higher Education, 2018). Therefore, the two concepts are rather different because educating students for careers as entrepreneurs differs from educating them to become self-reliant and proactive, with Jones and Iredale (2010) stressing the importance of a clear de-coupling of the two.

The research field of enterprise and entrepreneurship education has been characterised by wide variations and ambiguity regarding the use of concepts, especially when different national approaches are considered (Dal et al., 2016; Haara et al., 2016; Jones & Iredale, 2010). Despite this variation, the division into enterprise education, i.e., the broad interpretation, on one hand, and entrepreneurship education, i.e., the narrow interpretation, on the other hand, appears at the international (European Commission, 2004) and national (Dal et al., 2016) levels. As the broad interpretation (enterprise education) is concerned with developing characteristics and traits such as creativity, problem-solving, innovation, a proactive mindset and cooperation skills, it is not connected to specific subject content and is cross-curricular. Therefore, in fostering an enterprising self, the how of teaching and learning is regarded as more important than the what (Jones & Iredale, 2010; Pepin, 2012). Generally, enterprise education is more predominant in primary and secondary education, while business-oriented entrepreneurship education gradually grows in relevance from the secondary level onward (European Commission, 2004; Finnish Ministry of Education, 2009; Pepin, 2012).

One of the characteristics of enterprise education is that it is a policy-driven phenomenon (Dal et al., 2016; Hoppe, 2016; Mahieu, 2006). Its origins can be traced to the international policy level, and it can be found in several countries’ national core education curricula. From teachers’ perspective, this is relevant, as it means that enterprise education’s roots are not found necessarily within the development of the education sciences, nor is it found in grass-roots development at the practice level. Thus, teachers might find themselves faced with a policy-driven phenomenon that they are expected to implement without necessarily grasping it or even approving of it. Finding a balance between a cross-curricular focus and a subject focus is integral to this challenge (Elo, 2015).

On one hand, the expectations directed at schools demand a greater focus on enterprise education, a cross-curricular phenomenon. On the other hand, the education system’s basic structure still is rooted firmly in subject division and subject focus, i.e., acquiring subject knowledge is still important. This poses a challenge, particularly for subject teachers at the secondary and upper secondary levels, as both groups of teachers generally are educated and employed to teach specific subjects, so the subject-centric tradition is very tangible. Thus, a need exists to explore how the ambition to develop enterprising skills and competencies could be understood and realised within the existing education structure.
Open-ended investigations in science education

The rhetoric of criticising traditional teaching in favour of a more creative and student-centred approach found in the discourse on enterprise education also is found within science education. Hodson (2014) delineates four different approaches to science education: learning science, learning about science, doing science and addressing socio-scientific issues. Learning science is about “acquiring and developing conceptual and theoretical knowledge”. Learning about science concerns understanding the nature of science and how knowledge and theories in science are created. When doing science, students engage in scientific inquiry and problem solving. Finally, developing critical skills to make decisions concerning socio-scientific issues, such as environmental or moral-ethical issues, should be part of science teaching and learning.

The traditional approach to science teaching focuses on learning supported by carefully described curricular goals. It is based on a teacher-centred perspective in which “teachers are delivering science concepts and principles through primarily lecture mode” (Crawford, 2014), and student learning often remains on a rote learning level. Science Education for Responsible Citizenship (European Commission, 2015, p. 21) states: “Conventional modes in teaching and learning contribute little to developing innovation competencies”. Creativity and innovation are fundamental competencies for every human being in society today and tomorrow (Confederation of Finnish Industries, 2011; Daugbjerg, Lindfors, Dal, Henriksen, & Ottander, 2011; Finnish National Board of Education, 2016; Partnership for 21st Century Learning, 2015). The current discussion on science education emphasises cross-curricular goals, such as creativity or innovation, in the same manner as the discussion on enterprise education. An emphasis on creativity in school science should mirror the concept of scientific creativity and model the ways in which scientists work (Kind & Kind, 2007).

Much of the research-and-development work in science has been based on experimental work, resulting in school laboratory work becoming a standard feature of science education in many countries (Abrahams & Millar, 2008). However, traditional laboratory work in the science classroom has little in common with the researcher’s method of working, which calls for creativity, problem-solving, open-mindedness, perseverance, etc. Traditional physics and chemistry laboratory work in school generally is designed as recipes, in which students follow step-by-step instructions (Lunetta, Hofstein, & Clough, 2007), and for many teachers, this kind of laboratory work is still common in school laboratories (Hofstein, 2015) and often is viewed as a motivational factor (Aksela & Juvonen, 1999; Kurtén-Finnäs, 2008).

The teaching of science as inquiry can be traced back to Schwab (1962). In the early 1960s, Schwab highlighted the importance of a fundamental understanding of the nature of scientific inquiry, not only for scientists, but also for the usual “consumer”. Despite Schwab’s work, the teaching of science has been, and in many cases still is, teacher-oriented, focusing on concepts and principles, with laboratory work being of the recipe-type (Crawford, 2014). The impact of recipe-type laboratory work on students’ cognitive development has been a subject of considerable scrutiny (e.g., Abrahams & Millar, 2008; Hodson, 1993, 1996, 1998b; Hofstein & Lunetta, 2004; Jenkins, 1999; Lazarowitz & Tamir, 1994; Wellington, 1998). Many laboratory tasks are mere illustrations of phenomena and have little to do with scientific investigation.
They are hands-on, not minds-on, activities and provide a picture of science “as a fixed, algorithmic process in which a successful outcome (namely, the ‘right answer’) is virtually guaranteed if the sub-processes are carried out ‘correctly’” (Hodson, 1998b, p. 93).

However, since the late 20th century, a shift has occurred in views on practical work in science education. Inquiry-based teaching and learning have been highlighted in both policy documents, standards and curricula for teaching science (e.g., European Commission, 2007, 2015; Finnish National Board of Education, 2016; National Research Council [NRC], 1996, 2012; NGSS Lead States, 2013). A new vision of science education that includes the processes of science is described in the National Science Education Standards (NRC, 1996). In these standards, students’ opportunities to ask questions, plan and conduct investigations, choose and use appropriate tools to gather data, think critically, and analyse and communicate by using scientific inquiry are highlighted. Crawford (2014, p. 515) said teaching science as inquiry should “include both the pedagogy and the learning outcomes of inquiry, the pedagogy being the method of engaging students in designing and carrying out investigations and the learning outcomes referring to learning science subject matter by engaging in these investigations, in addition to learning ‘about’ the nature of scientific inquiry”.

Inquiry-based teaching in the laboratory varies from teacher-directed, structured inquiry, in which teachers present a research question and provide step-by-step guidelines on how to conduct the investigation. With open inquiries, students are responsible for the whole investigation, from posing a question to interpreting results and claims (Banchi & Bell, 2008). This division dates back to Schwab (1960), when he, in a corresponding way, described three different levels of inquiry in science: structured, guided and open inquiry. Open-ended investigations and open inquiry are used synonymously in this article as a description of the process of “doing science”.

Open-ended investigations are about learning to work scientifically. The learning goal is not primarily to arrive at the “correct answer”, nor should students follow just one path to find an answer (Glaesser, Gott, Roberts, & Cooper, 2009; Zion et al., 2004). An important learning goal is to develop an understanding of a scientific thinking process and acquire skills and competencies in connection with this. Scientific inquiry is holistic, fluid and reflexive, not a matter of following a set of rules that require a particular behaviour at a particular stage (Hodson, 1998a, p. 19, 2014). A scientist combines conceptual understanding with elements of creativity. Instead of being taught about creativity, Osborne, Collins, Ratcliffe, Millar, and Duschl (2003) allude to the importance of school science being a subject in which students genuinely can be creative. Although no single scientific method exists, the ones that do have common elements that can be represented in the inquiry cycle (Figure 1). Pedastre et al. (2015) also identify these elements in a review article.

Open-ended investigations start from a problem or a question, often from students’ own context or the world outside the science classroom. The problem-solving process in open inquiry requires creativity at almost all stages of the process. It “requires a student to explore his or her repertoire, to imagine a variety of routes to a solution and, frequently, to create novel combinations of knowledge or novel techniques for a solution” (Hu & Adey, 2002, p. 389). When formulating a hypothesis, students must use their prior knowledge and understanding to formulate a possible answer to the guiding question. Based on their hypotheses, students formulate research questions (Hofstein, Navon, Kipnis, & Malok-
Naaman, 2005), which is a central component of critical thinking, creative thinking and problem-solving, and is fundamental in science and science inquiry (Cuccio-Schirripa & Steiner, 2000; Dori & Herscovitz, 1999; Zoller, 1987; Zoller & Nahum, 2012). When “students have responsibility for posing questions” (Hodson, 2014, p. 2546), the questions will make sense for them and contribute to their motivation.

Questioning is an important aspect of a scientist’s work, and students’ ability to develop their questioning skills should be central to science education (Chin & Osborne, 2008; Osborne et al., 2003; Zoller, 1987). Several studies show that when students have the opportunity to formulate questions and develop them into researchable questions, their ability to ask higher-order questions and suggest questions for further investigations will develop (Hofstein et al., 2005; Hofstein, Shore, & Kipnis, 2004; Sadeh & Zion, 2012).

The design and planning of an investigation challenge students’ problem-solving skills and creativity. They must combine their prior cognitive knowledge with insights into how to conduct fair tests or other types of investigations, as well as activate their laboratory skills (Gott & Duggan, 1995; Kurtén-Finnäs, 2008). In this planning process, they must find and choose appropriate methods among perhaps several different methods to find the answer to their research question (Dori & Herscovitz, 1999). When students plan with their peers, different views of how to solve problems will arise, which can help them realise that several possible solutions to a problem may exist (Roth, 1993). Students must agree on a common solution in their small groups, which can develop their capacity for divergent thinking, described by Guilford (1967) as thinking in various directions, to arrive at a solution to a problem. Abilities relating to divergent thinking include the ability to produce several solutions to a problem and the ability to produce different and even uncommon solutions to a problem.
Kind and Kind (2007) point out that students, through creativity-training tasks, can develop the flexibility and ability necessary to handle changes in their future working lives. In an open-ended investigation, many different routes to a valid solution may be possible, as well as different uncertainties during the problem-solving process. This gives students opportunities to reflect and modify their practice (Glaesser et al., 2009). They also develop their ability and confidence to make decisions in ambiguous situations. In carrying out their plan, students’ may encounter several unforeseen problems that must be solved during the process, including problems with equipment or a realisation that the original plan does not work, forcing them to reassess the situation and devise a new strategy. This process challenges their problem-solving skills and creativity. When students plan their own investigations, different groups conduct different investigations, highlighting the need for students to share their results, defend and substantiate their conclusions, and remain open to discussion about possible variations in results (Kurtén-Finnäs, 2008; Roth, 1993).

Students’ work with open-ended investigations provides opportunities for interactions among peers and with their teachers (Lunetta et al., 2007). According to Katchevich, Hofstein, and Mamlok-Naaman (2013), students’ discussions and argumentation during open inquiry are richer compared with students’ argumentation during confirmatory-type experiments. The argument in the open-inquiry group, in their study, focuses on the hypothesis-building stage, analysis of results and on drawing appropriate conclusions. When students plan their own investigations, they also need to make their own decisions about how to organise and process their data to draw conclusions. This provides the opportunity for students to create different forms of presentations, from formal presentations or laboratory reports to poster and/or technological reports (Barrow, 2010).

Students’ work with open-ended investigations in science education is about doing science, and one important goal during their learning process is learning to work and think in a critical and scientific way. The challenges involved with students solving problems, finding answers to their own questions in cooperation with their peers, drawing conclusions and preparing presentations can present them with opportunities to use their imagination and develop proactivity and problem-solving skills.

Open-ended investigations: a form of enterprise education?

This section proceeds with an attempt to bridge enterprise education and open-ended investigations, by discussing similarities in two principal areas: the view of the learning process (how) and key goals (why). We position our article as a conceptual paper. According to Gilson and Goldberg (2015), a conceptual paper focuses on bridging or integrating previously separate phenomena, theories, disciplines, different levels or literatures, often with the aim to highlight directions for future inquiry. Providing a bridge or link is thus in focus, unlike in a traditional theoretical paper where the focus is on developing new theory constructs. This approach rests on a hermeneutic foundation, where the results emanate from historically and contextually situated reflexive interpretation (Alvesson & Sköldberg, 1994; Ödman, 2007).
**View of learning process**

Säljö (2010) argues that enterprise education rests on a view of knowledge as something produced and constructed in relation to a specific setting or problem, instead of being something possessed, which can be transferred or reproduced. Thus, learning becomes a process of interpreting and applying facts in relation to a situation, question or challenge, such as in an open-ended investigation in which students’ solution-based ideas are turned into action through a collaborative process of doing science (Hodson, 2014; Hofstein & Lunetta, 2004; Kurtén-Finnäs, 2008), rather than striving to reproduce facts by following recipes. Säljö’s (2010) description of enterprise education as the production of knowing, as something that is “done”, aligns with open-ended investigations’ focus: “doing science”. For both enterprise education and open-ended investigations, learning appears to be situated, pragmatic by nature and concerned with converting “… information to knowing in a manner that is consequential for the practice or issue engaged in” (Säljö, 2010, p. 34).

Therefore, the two phenomena rest on very similar views of the learning process. An open-ended, collaborative process of turning ideas into actions is at the core of enterprise education (e.g., Elo, 2016a, 2016b; European Parliament and Council, 2006; Garnett, 2013; Haara et al., 2016; Jones & Iredale, 2010; Moberg, 2014; Pepin, 2012; Quality Assurance Agency for Higher Education, 2018). The same process is the essence of open-ended investigations (e.g., Banchi & Bell, 2008; Gott & Duggan, 1995; Hodson, 2014; Jenkins, 1999; Finnish National Board of Education, 2016). The European Parliament and Council (2006, p. 17) states: “Entrepreneurship refers to an individual’s ability to turn ideas into action. It includes creativity, innovation and risk taking, as well as the ability to plan and manage projects in order to achieve objectives”. According to Moberg (2014, p. 517), the principal pedagogical idea of enterprise education “… is to teach the pupils how to transform their ideas into action by working in teams and using the team members’ different strengths and talents’. Several scholars stress that it is important that the ideas or problems that the learning process revolves around are student-initiated, resulting in holistic learning processes in which students are active in the planning, execution and evaluation of the iterative learning process (Elo, 2016b; Pepin, 2012; Rönkkö & Lepistö, 2016). Similarly, learners’ task in open-ended investigations is to define collaboratively the problem to be solved, create a strategy for the process of solving it and continuously evaluate whether the actions taken are in line with the desired result (Hodson, 2014).

The process of turning ideas into actions is characterised by the absence of pre-designed steps and a given method for solving a problem (Elo, 2016b; Hodson, 2014; Kurtén-Finnäs, 2008; Sadeh & Zion, 2012). In such a process, the students, steered by the task, define a desired end result and set up a strategy for achieving it, dealing with unforeseen problems and the ambiguity of the process as it evolves (Elo, 2016b; Elo & Kaihovirta, 2017; Pepin, 2012; Zion & Mendelovici, 2012). Pepin (2012) stresses the importance of reflection before, during and after action, within the process. One of the traits that this process is meant to develop is learner proactivity (Elo, 2015; Gott & Duggan, 2007; Hodson, 2014; Moberg, 2014). In this context, proactivity encompasses the ability to set goals and actively work toward reaching them.
Key goals

In addition to sharing a common view of the learning process, the two phenomena also share similar key goals. Both enterprise education (e.g., Cankar, Deutsch, Zupan, & Cankar, 2013; European Commission, 2004; Hietanen & Järvi, 2015; Jones & Iredale, 2010; Leffler & Näström, 2014; Moberg, 2014; Sjøvoll, 2010, 2011) and open-ended investigations (e.g., Barrow, 2010; Dori & Herscovitz, 1999; Hu & Adey, 2002; Osborne et al., 2003) emphasise the learner’s development of creative and innovative capacities as their key goals. Within enterprise education, creative and innovative capacities are regarded as prerequisites for coping in a rapidly changing, global world, for societies as well as for individuals, and also are viewed as essential in the dynamic and constantly transforming working life, strongly linked to economic competitiveness (Skogen & Sjøvoll, 2010). Within science education, creative and innovative capacities also are viewed as important skills for future citizens, but primarily, these capacities are emphasised as core components of the process of scientific investigation in doing science (Dori & Herscovitz, 1999; Hodson, 2014; Osborne et al., 2003).

Though both phenomena share the ambition of developing creativity and innovation, the arguments concerning their importance are somewhat different. For enterprise education, creativity and innovation are key competencies for coping in society in general and in business in particular. Within open-ended investigations, creativity and innovation mainly are viewed as key competencies in the scientific process of discovery, as well as the development of new knowledge. "Scientific research requires creativity in the sense of going beyond existing knowledge and techniques, of creating new understanding" (Hu & Adey, 2002, p. 389). However, the larger context of science education shares much of the policy rhetoric and context concerning creativity and innovation with enterprise education (e.g., European Commission, 2004, 2015; European Parliament and Council, 2006).

Closely linked to both creativity and innovation, as well as a learning process of turning ideas into action, is developing the learner’s problem-solving skills. This is emphasised in both open-ended investigations (e.g., Chin & Osborne, 2008; Cuccio-Schirripa & Steiner, 2000; Dori & Herscovitz, 1999; Hodson, 2014; Zoller, 1987) and enterprise education (e.g., Cankar et al., 2013; Diehl & Olovsson, 2017; Elo, 2016b; Kupferberg, 2014; Leffler & Näström, 2014; Pepin, 2012; Sjøvoll, 2010). Jones and Iredale (2010, p. 37) list problem solving as one of the key characteristics of enterprise education: “Enterprise education is very much about teamwork, confidence building, problem solving ...”. Kupferberg (2014) goes one step further by suggesting that problem-based learning generally is a form of enterprise education, viewing both as somewhat synonymous.

Within enterprise education, the importance of the ability to solve problems individually or collaboratively is stressed, both in the fields of working life and business, as well as in the more private spheres of life in general (Finnish Ministry of Education, 2009; Leffler & Näström, 2014; Regeringskansliet, 2009). In science education, the ability to solve problems is stressed as a prerequisite of the scientific process of doing science (Dori & Herscovitz, 1999; Hodson, 2014; Zoller, 1987). Hodson (2014, p. 2537) describes doing science as “engaging in and developing expertise in scientific inquiry and problem-solving”. The fact that both phenomena emphasise problem solving is rather natural, as both rest on a process-oriented view of learning based on solving open-ended tasks. Thus, problem solving is at the core of the process, which begins with...
defining a primary problem or challenge to be solved. As the process progresses, several unanticipated secondary problems and challenges are identified, then solved (Elo & Kaihovirta, 2017). Therefore, during a process of this nature, both the strategy and the results’ vision constantly are transforming (Elo, 2016b; Elo & Kaihovirta, 2017). Although the basis for the arguments regarding the importance of problem solving differs, a common feature lies in both fields criticising traditional teaching for not addressing this common goal.

In the context of enterprise education, developing the capacity for decision-making also is highlighted as a key goal (e.g., Dahlstedt & Hertzberg, 2011; Elo, 2016b; Elo & Kaihovirta, 2017; Haataja, Hietanen, Järvi, & Tampuri, 2009; Hietanen & Järvi, 2015; Regeringskansliet, 2009; Rönkkö & Lepistö, 2016). The development of students’ ability and confidence in making decisions in ambiguous situations is contrasted with making “right or wrong” decisions (Elo, 2015, 2016b; Rönkkö & Lepistö, 2016). Learning to make decisions in situations in which the question and possible answers are ambiguous is viewed as a key competency in society at large, as well as specifically for entrepreneurship.

When discussing decision-making in the context of enterprise education, Rönkkö and Lepistö (2016, p. 50) claim that: “Being able to make decisions that affect them at school encourages students to make independent and future-focussed decisions in their own lives”.

Competence and confidence in decision-making, supported by divergent thinking, also are at the core of open-ended investigations (e.g., Glaesser et al., 2009; Zoller, 1987). Focusing on doing science, involves students deciding what course of action to take to solve the problem at hand or produce the desired result. This engages students in situations in which they must make constant choices based on the information and knowledge at hand. These decisions emerge at all stages of the inquiry circle: “Students are engaged in continuous decision-making throughout each stage of the open-inquiry process, starting from the stage of finding the interesting phenomenon to be inquired” (Zion & Mendelovici, 2012, p. 383).

One characteristic of these kinds of situations is that they are not focussed on finding the right answer to a well-defined question. Instead, the decision-maker must begin by defining and analysing the problem or decision at hand, then continuing toward identifying and evaluating the probable outcomes of different possible courses of action in that particular context. Thus, the task is not to identify a single correct decision, but rather to make a decision that is most likely to produce a desirable outcome under the prevailing circumstances (Elo, 2016b; Elo & Kaihovirta, 2017; Rönkkö & Lepistö, 2016). Both enterprise education and open-ended investigations critique traditional teaching for being based on ready-made answers and not creating space for divergent thinking and decision-making. However, the basis for substantiating the importance of decision-making differs. In enterprise education, decision-making is highlighted, as it is viewed as a prerequisite for coping in a constantly transforming contemporary society, particularly working life and the business world, whereas in open investigations, it is regarded as a core competency for doing science.

The final common learning goal examined in this article is the ambition to develop the ability to collaborate. This is highlighted continuously in extant literature on open-ended investigations (e.g., Hodson, 2014; Hofstein & Lunetta, 2004; Hofstein et al., 2004; Roth, 1995), as well as enterprise education (Finnish Ministry of Education, 2009; Garnett, 2013; Leffler & Näström, 2014; Leffler et al., 2010; Lelinge & Widén, 2014; Moberg, 2014;
The European Parliament and Council (2006) has declared that the skills that entrepreneurship education aims to develop include “... proactive project management (...), effective representation and negotiation and the ability to work both as an individual and collaboratively in teams”. Thus, developing the ability to cooperate is viewed as beneficial mainly in a working-life context, even though it is related to the private and public life spheres as well. In open-ended investigations, the importance of cooperation and combining students’ strengths within the overarching process of turning ideas into action specifically is highlighted, as this is viewed as a characteristic of open inquiry (Hodson, 2014; Roth, 1993). Both share a view of learning as something that is socially distributed, occurring in reflexive actions and interactions.

In the preceding discussion, we have attempted to bridge open-ended investigations and enterprise education by pointing out the similarities in the view of the learning process and the key goals. The discussion shows that both phenomena appear to rely on a common, rather pragmatic, view of knowledge as something constructed in relation to a challenge or problem. Learning is perceived as something that is “done” in a collaborative, open-ended and holistic learning process that builds on reflexive problem-solving. Both phenomena emphasise developing the capacity for problem solving, decision-making, creativity, innovation and collaboration as key learning goals. Overall, the two phenomena thus share many similarities.

It should be noted that this attempt to bridge the phenomena is not exhaustive, but does point to similarities, implying that open-ended investigations can be viewed as a way to implement enterprise education in science education, thereby exemplifying how a cross-curricular theme can be combined with a specific subject without compromising subject teaching. Next, we discuss this article’s implications.

**Conclusions and implications**

The comparison above reveals several points of contact between open-ended investigations and enterprise education, regarding the “how?” and “why?” questions of teaching. Regarding the how-question, both rest on a similar view of learning, with a focus on a student-driven, reflexive and open-ended collaborative learning process aimed at turning students’ ideas into action. Regarding the why-question, both emphasise creativity, innovation, problem-solving and the importance of decision-making in open-ended collaborative processes as key goals. Furthermore, both share rhetoric that criticises traditional teaching’s narrow focus on ready-made questions with pre-defined answers.

Despite these similarities, the two phenomena also differ and have their own distinct features. Within enterprise education, the arguments for the importance of its approach to learning and the associated goals lie in the perceived need for proactive, self-reliant and entrepreneurial individuals in contemporary society. Enterprise education’s roots lie in the international-policy level, and it has been present on the policy agenda since the 1980s in the important milestone reports *Toward an “Enterprising” Culture: A Challenge for Education and Training* (OECD/CERI, 1989) and, nearly 10 years later, *Fostering Entrepreneurship* (OECD, 1998).

While the roots of enterprise education began at the policy level (Dal et al., 2016; Hoppe, 2016; Mahieu, 2006), the roots of the discussion on open-ended investigation date back to Schwab (1960), who highlighted an understanding of the nature of
scientific inquiry in the early 1960s. Despite this, the laboratory work in school science during the following decades primarily was designed as recipes (e.g., Hodson, 1996). Open-ended investigations emerged in the late 20th century as an alternative to traditional recipe labs, championing the need for school laboratory work to correspond with real scientists’ work, with an emphasis on *doing science*. This approach was perceived as rendering better in-depth learning results for students.

As the comparison shows, the roots of open-ended investigations originally lie in the ambition to develop subject teaching, while the roots of enterprise education lie mainly in international policy. However, in the current context, both science education and enterprise education can be viewed as sharing much of the same policy context and rhetoric, e.g., on the European level (e.g., European Commission, 2004, 2015; European Parliament and Council, 2006). As the contemporary discussion on open-ended investigations is part of the wider discussion on science education, it would be a mistake to assume that open-ended investigations in the current debate are a policy-neutral phenomenon.

The results of our comparison provide one example of when the implementation of a specific method for teaching subject content simultaneously can be viewed as a way to integrate a cross-curricular phenomenon. Thus, learning science through open-ended investigations simultaneously would be a means to realise enterprise education *through* science education, not at the expense of it. Therefore, the results provide new knowledge on the under-researched area of connections between enterprise education and school subjects, and the results may be useful for teachers, teacher education, educational researchers and curriculum development.

This article is the result of a reflexive dialogue that attempted to bridge a school subject and a cross-curricular phenomenon. Therefore, the results imply that an important area for further development and research comprises such boundary-crossing dialogues that bridge different phenomena on the educational agenda. In educational systems based on subject division, development and dialogue tend to remain within separate subject domains, resulting in cross-curricular connections remaining unnoticed. The same applies to research. As long as the dialogue remains within the domains of individual subjects or phenomena, connections to other educational phenomena remain unnoticed and unexplored. Emphasising this cross-curricular dialogue also carries implications for curriculum development and educational leadership. A prerequisite for successfully implementing and developing cross-curricular phenomena is that the connections between these phenomena and the school subjects are made explicit. This would call for research-informed curriculum development and educational leadership, based on a cross-curricular dialogue at all levels: local, regional, national and international. This dialogue presumably would be equally important in both teacher education and teachers’ continuing professional development. An emphasis on a cross-curricular dialogue also calls into question whether national and international high-stakes student evaluations, focused on subjects, can be viewed as counterproductive to this dialogue and, thus, counterproductive to a focus on cross-curricular goals in general.

This paper naturally has limitations. The results are based on reflexive interpretations of two phenomena on the educational agenda, through a dialogue between two researchers within the respective fields: open-ended investigations and enterprise education. Naturally, an examination by different researchers might have produced at least somewhat different results. Nevertheless, the results can be viewed as well-grounded examples of how these two phenomena can be bridged and as an opening for further cross-curricular dialogue.
between enterprise education and science education. Possible future areas of research could be to continue exploring suggested points of contact at the level of practice through action-research initiatives. This would add knowledge and insights on the connections and conflicts between enterprise education and open-ended investigations. As our article only has outlined how these two phenomena can be bridged, future studies also could focus on exploring some of the outlined points of contact in more depth. At a general level, our suggestion is to increase and support the cross-curricular dialogue at the level of research, policy, educational leadership and practice levels of individual schools and teachers. Developing this dialogue could prove to be a fertile ground for discovering unnoticed connections, as well as moving beyond a limited perspective of subject focus.

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