Students' narratives and conceptual changes in a cross-curricular inquiry-based study unit in a Finnish upper secondary school

Kuisma, Merja; Ratinen, Ilkka

ELSEVIER

Students' narratives and conceptual changes in a cross-curricular inquiry-based study unit in a Finnish upper secondary school

Merja Kuisma [a],[*], Ilkka Ratinen [b]

[a] *Tampere University, Kalevantie 4, 33014 Tampere University, Finland*
[b] *University of Lapland, Yliopistonkatu 8, 96300 Rovaniemi, Finland*

ARTICLE INFO

ABSTRACT

Cross-curricularity is being implemented in the upper secondary school curriculum reform in Finland. This study investigates changes in conceptual constructs when studying humans and humanity from the points of view of six school subjects (biology, physics, physical education, philosophy, psychology and arts) in a pilot study unit. We found evidence of changes in conceptual constructs with vast individual differences. Learners with a mastery goal orientation manifested conceptual change, belief revision and threshold concepts the most. "Learning deepened by autonomy" was the dominant narrative in the students' narrative interviews. Two counternarratives, "struggling with motivation and schedule" and "active communicator with poor effort regulation", in which learners' self-regulated learning skills were poorer, were also identified.

1. Introduction

Upper secondary schools in Finland started to implement the new national curriculum in August 2021 (Finnish National Agency for Education, 2021). One of its aim is to establish a balance between subject knowledge delivery and cross-curricular learning opportunities with transversal competence areas: (1) well-being competence, (2) interaction skills, (3) multidisciplinary and creative competence, (4) civic skills, (5) ethical and environmental competence and (6) global and cultural competence. These competences are implemented at the national level within each school subject and within locally developed cross-curricular study units.

This study will find out how this new cross-curricular approach can be implemented at an upper secondary school. For this study, a local pilot study unit named "Human being – What am I" was developed in the Teacher Training School of Tampere as part of a project funded by the Ministry of Education and Culture. The project aims to formulate scalable teaching and learning models for all upper secondary schools in Finland to implement in curriculum reform. The concept pilot study unit was applied as the aim was to test study units' implementation locally before disseminating them for all upper secondary schools in Finland. The study unit in question embraces competence areas 1–3, as one aim is to enable students to be not only content specialists but also coherent communicators of interdisciplinary themes (Dannels & Housley Gaffney, 2009). Inquiry learning was chosen as a teaching and learning model to enhance deeper learning (e.g., Duran & Dökme, 2016; Paavola & Hakkarainen, 2005). Learning proceeds cyclically as the learners formulate questions according to their previous knowledge. This model fits this context well as learners study a common theme, humans, from the different perspectives presented by six school subjects.

---

* Corresponding author.
  E-mail addresses: merja.kuisma@tuni.fi (M. Kuisma), ilkka.ratinen@ulapland.fi (I. Ratinen).

This is the third independent study of the three case studies together composing an action research study dealing with theory based pedagogical models of inquiry learning. This study aims to investigate how learners with different personal achievement goal orientations manifest changes in conceptual constructs and combine views of different school subjects in a cross-curricular study unit when they are given great autonomy over their tasks. We chose this approach because goal orientation has been linked to cognitive, affective and behavioural processes which affect academic learning outcomes (Dweck, 1986; Pintrich, 2003; Skaalvik, 1997). Moreover, we investigated conceptual change (Chi, 1997; Vosniadou, 1994) and threshold concepts (e.g., Land et al., 2010) because there were six school subjects from different scientific disciplines: biology, physics, physical education, philosophy, psychology, and arts; hence, the domain and its theoretical framework changed during the study unit. Several studies have investigated changes in conceptual constructs in different disciplines, especially in the field of science, but studies in an upper secondary cross-curricular context are nonexistent (Flanagan, 2020). Thus, this study seeks to contribute to filling this research gap.

2. Theoretical framework and research questions

2.1. Cross-curricular approach

The terms concerning curriculum integration when combining different school subjects around a common theme vary from "cross-curricular" to "interdisciplinary". Their definitions and implementation procedures share common features: Cross-curricular, multi-disciplinary and interdisciplinary curricula should all involve not only increased motivation but also promoting understanding in relation to another subject (Beane, 1997; Fogarty, 1995; Heywood & Solomon, 2012; Jacobs, 1989; Savage, 2011). They are implemented in teaching and learning in various ways, yet their implications and theoretical background are understudied. We justify the course design and pedagogical practices of our study unit by referring to the pedagogical research tradition of exploiting the similarities between subjects in terms of content, pedagogies, and enhanced engagement and creativity via the application of multiple subjects to a common focus. We apply the following definition by (Savage (2011), pp. 7-8))

A cross-curricular approach to teaching is characterized by sensitivity towards, and a synthesis of, knowledge, skills and understanding from various subject areas. These inform an enriched pedagogy that promotes an approach to learning which embraces and explores this wider sensitivity through various methods.

Through our findings on changes in the conceptual constructs of learners with different goal orientations and self-regulated learning (SRL) skills, we aim to add to the discourse on curriculum integration.

2.2. Self-regulated learning

In this study, SRL is defined as an "active, constructive process whereby learners set goals for their learning and attempt to monitor, regulate and control their cognition, motivation, and behaviour, guided and constrained by their goals and contextual features in the environment" (Pintrich, 2000, p. 453). No research has been conducted on SRL implementation in cross-curricular learning in upper secondary schools. Therefore, we investigated SRL as a task-related event rather than an individual's long-term characteristic (Perry, 2002) by analysing the students' self-reported stories from cross-curricular courses that are narrated as portfolio texts or narratives formulated in an interview. Metacognitive knowledge and metacognitive regulation are widely regarded as constructs of SRL (e.g., Alexander, 1995; Boekaerts, 1995; Corno, 1995; Winne, 1995; Zimmerman, 1995), and knowledge of cognition and regulation of cognition are seen as components of metacognition (e.g., Brown, 1978). Students' learning diaries and portfolios both reveal and support their metacognition – that is, knowledge of their own cognition for supporting SRL.

Inquiry learning requires great autonomy from learners; thus, they need to use SRL skills and they need support from the teacher (Kuisma, 2018; Winne, 1995). To facilitate SRL, learners' behaviour should be intrinsic and not regulated by the teacher, parents or peers (Zimmerman, 1998); hence, careful planning of guidance is essential. Self-regulatory skills are not permanent characteristics of individuals but are affected by contextual, developmental and individual factors (Kuisma & Nokelainen, 2018; Loyens et al., 2008; Wolters, Pintrich, & Karabenick, 2003). We chose an inquiry-based teaching and learning model because we wanted to strengthen learners' SRL skills. These skills are strengthened as adolescents gain experience in controlling their behaviour (especially effort regulation, management of the study schedule and physical learning environment) as well as cognition and motivation (Kuisma, 2018; Winne, 1995; Wolters, Pintrich, & Karabenick, 2003).

2.3. Inquiry learning

Learners' competence at the cognitive and metacognitive levels as well as subject-related competences, such as conceptual competence, are needed for the knowledge-building processes of inquiry learning (Kuisma & Nokelainen, 2018; Le Deist & Winterton, 2005). Thus, the study unit in question was targeted at senior students. Instruction should focus on all three dimensions (metacognitive, motivational and behavioural) of SRL to succeed in promoting long-term effects on SRL skills (Zimmerman, 1990). This was taken into account when designing the learning diary and portfolio instructions (Appendix B) as tools for inquiry learning for the study unit. According to Bell and colleagues (Bell et al., (2010 p. 349)), collaborative inquiry learning is "a promising culture of teaching and learning … where students in groups engage in self-regulated learning activities supported by the teacher". The nine inquiry processes are (1) orientation and question making, (2) hypothesis generation, (3) planning, (4) investigation, (5) analysis and interpretation, (6) model exploration and creation, (7) conclusion and evaluation, (8) communication and (9) prediction. The degree of openness of the instruction can vary from giving the learner the opportunity to form research questions freely and collect data independently to

providing the learner with the questions and data (Bell et al., 2005). An activity can be viewed as inquiry based as long as learners conduct the analysis themselves and draw their own conclusions. The most demanding level with the most learner autonomy requires substantial knowledge scaffolding and was not applied in the lesson tasks, but the continuing learning diary and portfolio task with the requirement of formulating research questions is regarded as the most demanding level of inquiry learning.

In this study, we applied the model for a cross-disciplinary course which combines the views of natural science (biology and physics) with the views of psychology, philosophy, physical education and arts. The students were given lower-level inquiry activities as lesson tasks because they only had three lessons of 75 minutes per subject. Moreover, because of the complexity of the learning and SRL processes, we cannot assume that student-centred inquiry learning always promotes SRL skills (English & Kitsantas, 2013). Hence, we investigated SRL skills based on the students' narratives and learning outcomes (learning diaries, portfolios, and concept maps).

2.4. Conceptual change, enrichment, belief revision and threshold concepts

We aimed to investigate the changes in students' conceptual constructs during the learning processes of a cross-curricular study unit. This is especially interesting because the domain with its theoretical framework grounded in different epistemological and ontological views changes during the study unit. We studied whether the conceptual construct changes could be detected as enrichment, which entails adding new information to existing conceptual structures, or whether there would be belief revision, which is regarded as a change in the learner's beliefs or in the perception of a theory (Vosniadou, 1994). In belief revision, beliefs are tied to and constrained by certain ontological and epistemological presuppositions. Therefore, beliefs instead of smaller fragmented structures create a uniform structure.

People store concepts and situations on ontologically distinct associative trees (Chi, 1997). These "trees" can form barriers restricting our understanding and creativity; thus, we should be able to cross these barriers in a flexible way. When a person re-represents an entity in a new way, they switch from one ontological multi-branched tree of concepts and categories to another. A category means a set of objects that are believed to belong together. When people encounter new objects, they consider them members of a certain category and label them accordingly. Thus, people have a cognitive advantage when they use these familiar categories because they reduce the demand for processes such as storing and reasoning. A conceptual shift can occur among the branches of the same ontological tree; we regard this as either enrichment of the concept or belief revision (Vosniadou, 1994) if the change is related to the whole belief construct. If a person changed the entire ontological tree to which the concepts belong, it would require changes in a vast number of attributes linked to the concepts in question. Consistent with Chi (1997), we define conceptual change as shifting a concept from one ontological tree to another.

The most difficult and most creative shifts are the ones where concepts and their attributes shift across entire ontological trees. The sudden "aha moment" is regarded as a phenomenon of creativity, where every piece suddenly falls into place (Chi, 1997). This phenomenon can be viewed as an ontological shift because a concept that moves from one ontological tree to another inherits all the attributes of the first tree. Moreover, what may seem like trivial conceptual shifts from one person's perspective may be ontologically significant from another person's perspective (Chi & Brem, 2009). When a person detects a paradox concerning a new concept and its categorisation, it can trigger conceptual change (Bereiter, 1985; Chi, 1997; Chi & Brem, 2009). There can be anomalies in learners' concept categories, which can be left unchanged, especially if the learner is extremely committed to their current theories. In that case, conceptual changes do not happen. One can explain and accept these anomalies, thus expanding the current theory, as suggested by Ohlsson (2009), or one can make a belief revision or a conceptual change to avoid the problematic contrast.

We also aimed to identify possible threshold concepts. A threshold concept is always transformative, which means that it changes one's understanding or interpretation of something (Meyer & Land, 2003). Threshold concepts must be understood to progress in learning as they are gateways to understanding the critical content of a discipline. Threshold concepts transform learners by allowing them to view matters as biologists, philosophers, artists and so on; perceiving a threshold concept involves both an ontological and a conceptual shift. A threshold concept can be detected as a kind of gateway to the challenging content of a certain discipline, such as "genetic variation" in biology, "gravity" in physics or "personhood" in philosophy (Batzli et al., 2016; Land et al., 2010). Many learners tend to get stuck with threshold concepts and need support from the teacher to overcome this obstacle and learn the subject matter. Schwartzman (2010) suggested that crucial elements behind the difficult experience are unrelated to the disciplinary context. Instead, experiences of difficulty are based on reflective and defensive responses to rupture, which results from encountering existentially unfamiliar constructs. In other words, the foundation of a threshold concept is discipline independent by nature. The time frame following the encounter with the threshold concept can be viewed as Heidegger's "dynamic of rupture", as the learner's response is constructed in an explicit form by either reflectiveness or defensiveness. This results in a time frame of confusion and uncertainty by the learner. We investigated whether enrichment, belief revision, conceptual change or threshold concepts emerged by analysing learners' diaries, portfolios and concept maps and by conducting narrative interviews.

2.5. Objectives of the study and research questions

As subject teachers and teacher trainers, we are interested in knowing what kinds of narratives learners of different SRL skills and personal achievement goal orientations formulate about the cross-curricular study unit, thus this is referred to as our main research question (MRQ). This includes investigating how students perceive inquiry learning with a learning diary and portfolio as a method of learning. We address this main question also by following sub-research questions (SRQ): (1) How students of different personal achievement goal orientations perceive the points of view of different disciplines and their possible synergy and (2) can changes be detected in students' conceptual structures when they ponder different topics and perspectives of the cross-curricular study unit. The

research questions (RQs) are as follows:

MRQ What kinds of narratives from the points of view of SRL and inquiry learning do students formulate when they are interviewed?

SRQ1 How do personal achievement goal orientation profiles relate to the level of complexity and depth narrated in the portfolios and narrative interviews?

SRQ2 How does cross-curricular inquiry-based teaching and learning affect conceptual constructs (enrichment, belief revision, conceptual change, and threshold concepts)?

3. Methods

3.1. Participants

The study took place in the Pirkanmaa region of Central Finland. It investigated a pilot study unit in the Teacher Training School of Tampere as part of a project called "Cross-curricular learning in the general upper secondary school", funded by the Ministry of Education and Culture. The project is coordinated by Aalto University and Tampere University, and it aims to formulate scalable teaching and learning models for all upper secondary schools in Finland to implement in curriculum reform. There were 10 students in the class, and their ages ranged from 17 to 18 years. All the students were given pseudonyms. Only one male student was involved, so he was given a female pseudonym to protect his identity. Six subject teachers were involved, and one of the researchers had a double role as she was also the biology teacher. The study was an independent part of a wider dissertation study authorised by the Ethics Committee of the Tampere region and the participating school's headmaster. Participation in the study was voluntary, and learners provided written informed consent. They were also given a detailed privacy notice via email.

3.2. Data collection

We investigated changes in students' conceptual constructs by monitoring the process from the outside through their subject teachers and the researcher. The teachers and researcher kept diaries of their observations. The lessons were videotaped to keep a record of any signs of changes in conceptual constructs during the lessons. Parallel multimodal data were collected and analysed by triangulation, as multimodal data has been shown to provide different perspectives to learners' learning process and to better predict their learning outcomes (Cukurova et al., 2019; Giannakos et al., 2019).

3.2.1. Learning diaries and portfolios

Students kept learning diaries to help with their portfolios about how well they felt they had learned the subject matter, what concepts they had learned and which questions they wanted to find answers to (Appendix B). In this way, we gathered data about students' individual learning goals and achievement of these objectives. Students were instructed to ponder the meanings of the concepts, other ideas and observations of their learning process in their portfolios. The portfolios were graded by the six teachers on a scale of 1 to 3. When the assessment of portfolios by the teachers and the researcher were compared, no significant differences were detected.

3.2.2. Questionnaire on personal achievement goal orientations

At the beginning of the study unit, the students answered a questionnaire about their personal achievement goal orientations. The questionnaire was used to assess the relationships between students' learning outcomes (learning diaries, portfolios and concept maps) and the conceptual changes expressed in the narrative interviews. The questionnaire belongs to the Patterns of Adaptive Learning Scales (PALS) developed by Midgley and colleagues (2000). Their questionnaire was derived from goal orientation theory, which tackles the relationship between the learning environment and students' motivation, affect and behaviour. We chose the questionnaire to assess students' learning outcomes according to their mastery (six items), performance-approach (five items), and performance-avoidance (six items) goal orientation profile. The questionnaire uses a 5-point Likert scale (1 = not at all true, 3 = somewhat true, 5 = very true).

Personal achievement goal orientation investigates why learners engage in academic behaviour Midgley and colleagues (2000). Three different goals reveal different patterns, including cognitive, affective and behavioural components, which have been characterised as more or less adaptive. The first purpose of academic learning is labelled mastery goal orientation, where learners' goal is to develop their competence. Learners aim to deepen and broaden their understanding; as such, learning is perceived as interesting, and learners' focus is fixated on the task. The second purpose of academic learning is labelled performance-approach goal orientation. Learners aim to demonstrate their competence to the teacher and to other students, and their focus is fixated on the self. The mastery goal orientation approach has been associated with adaptive patterns of learning, whereas the performance-approach goal orientation has been associated with both adaptive and maladaptive patterns of learning (Pintrich, 2003). The third purpose of academic learning is labelled performance-avoidance goal orientation, where learners' purpose is to avoid the demonstration of incompetence (Midgley et al., 2000). Learners' attention is focused on the self, and their orientation is associated with maladaptive patterns of learning. In addition to demonstrating high ability, learners with a performance-approach goal orientation are focused on achieving at higher levels than others. By contrast, learners with a performance-avoidance goal orientation are concerned with avoiding the demonstration of low ability or appearing stupid (Pintrich, 2003). Adaptive processes refer to, for example, learners' abilities to calibrate their behaviour and cognition and not to constantly over- or underestimate their capabilities and then lose motivation as a result of negative

feedback.

One of the background views is Dwecks (1986) suggestion of motivational processes affecting children's knowledge acquisition, knowledge transfer and use of skills. When children aim for certain learning or performance goals, it shapes their reactions to success or failure and the quality of their cognitive learning outcomes. In other words, Dweck's model depicts adaptive and maladaptive learning patterns which affect learners' cognitive learning outcomes. Moreover, the scales for personal achievement goal orientations differ between the performance-approach and performance-avoidance dimensions (Middleton & Midgley, 1997). Therefore, there are items measuring (1) the goal of developing ability, (2) the goal of demonstrating ability and (3) the goal of avoiding the demonstration of a lack of ability.

In our study, we applied the items to measure studying in school in general. The items can also be refined to suit each school subject in a domain-specific way, but we used the scales to depict a general goal approach profile for each learner. Because the study unit that was investigated is voluntary for the students, we expected higher scores in mastery goal orientation than in performance-approach or performance-avoidance goal orientation. Based on previous studies about goal orientation profiles (see Pulkka & Niemivirta, 2013, 2015; Tuominen-Soini, Salmela-Aro, & Niemivirta, 2012), we expected to find (a) most learners focusing on learning new things and gaining competence, (b) some learners focusing on demonstrating their competence, (c) some learners with an emphasis on the avoidance of failure, (d) learners with a combined emphasis on mastery and performance goal orientations and (e) learners with no clear goal preferences.

3.2.3. Concept maps and qualitative narrative interviews

To explore what the learners perceived as key concepts and their connections, they were asked to draw a concept map of the most meaningful concepts they had encountered in the study unit. In this way, learners' conceptual structuring was made visible (Novak, 2010; Novak & Cañas, 2008). Concept maps were analysed through content analysis and in a quantitative way by counting the concepts and links (propositions) for each concept. The more links to a concept, the more meaningful it is for the learner. As the concept map was made hierarchically, the higher the concept is situated, the more meaningful it is for the learner.

A qualitative narrative inquiry approach was chosen because it focuses on an in-depth understanding of the events (Abbott, 2008; Kuisma, 2018) that took place during the study unit from the students' point of view. According to constructivism, people construct both knowledge and their identities by placing new constructs upon previous ones (Heikkinen, 2015); thus, knowledge is created subjectively as an interplay between one's prior experiences, conceptions, and new ideas. As individuals' conceptions of themselves and the surrounding world are always changing, an ever-changing narrative emerges (Bakhtin, 1986; Guba & Lincoln, 2005), and knowledge can be regarded as a network of these narratives. In our research, the narratives have two-dimensional characteristics because they are both the target of research (analysis of narratives) and its outcome (narrative analysis). The orientation of our study was cross-sectional as we focused on investigating what kinds of narratives interviewees would produce at the end of the study unit. An autobiographical approach was chosen because we focused on the events of the story – more precisely, what happened and why — rather than investigating the structures and forms of these narratives with a more linguistic approach (Abbott, 2008). Therefore, both the scientific classical realistic paradigm and constructivist interpretative paradigm are equally present.

We used the one-question narrative interview introduced by Fritz Schütze (Hyvärinen & Löyttyniemi, 2005; Rosenthal, 2004; Rosenthal, 2003; Wengraf, 2001). Students were asked one question to guide them into storytelling. After a narrative or short answer, the second phase of the interview followed, with questions derived from the previous answer. The last phase of the interview involved asking questions that were in the interest of the researcher for the current study (Appendix C) if these topics had not been addressed already. Therefore, the interviewer cannot be regarded as an objective bystander but as an active participant in the interview process. Furthermore, the students were regarded as experts of learning; to avoid alienating adolescents from their experiences through a formal question-answer setting and formal language, we decided not to use a structured or semi-structured interview but instead gave them more freedom to express themselves in their own words in a narrative interview.

The objectives of the narrative interview were to understand the past events of a cross-curricular study unit and to induce the adolescents into reshaping their experiences into an understandable narrative format. It was regarded as an extra benefit if the interview process led to the learners' self-reflection and they came to acknowledge their strengths in the learning process. All 10 students volunteered to participate in the interviews. Two students (Jannika and Katriina) wanted to be interviewed together, which was allowed to minimise their anxiety. The narrative interviews took an average of 45 minutes (ranging from 31 to 68 minutes).

3.3. Analysis techniques and reliability of the narrative analysis

A narrative analysis of the narrative interviews was done by composing composite narratives (Kuisma, 2018; Willis, 2019(Willis, 2019)). First, thematic analysis was used to categorise individual narratives according to the themes of the research questions (see section 4.1). Two researchers read the transcribed interviews and compared the results of their thematic analysis (Armstrong et al., 1997). The discrepancies were discussed, and some modifications were made to the individual narratives. Second, the most frequently detected narrative was identified and labelled the dominant narrative, and the others were labelled counternarratives.

The interviews were conducted and transcribed in the students' mother tongue, Finnish. After the transcripts were read through for the third time, a summary was made of each interview by extracting the key quotations. These individual narratives were translated into English, aiming for the most valid interpretation of the narrative rather than an accurate word-to-word translation with the finest semantic and linguistic details (Nikander, 2008), as the analysis of this study is more content oriented than interaction oriented. Next, composite narratives were made by combining the individual summaries sharing the same theme. Translation and combining were done to secure the precision and accuracy of the narratives and to ensure the readers of analytic transparency. The composite

Table 1

Programme of the study unit.

Discipline(s)	Topics and tasks
All six teachers (BI, PE, PHY, PHI, PSY, Arts)	Instructions; introductory lecture about the different approaches to humans according to existentialism, essentialism and naturalism, and culturalism (PHI); students start making their individual learning diaries
BI	Lecture about sensory systems of humans compared to other animals to give the students a biological point of view on humans compared to other animals and to create a context for the next lessons
BI	Students investigated the human senses in pairs.
e.g. Olfaction and taste: "Dry your tongue with kitchen paper and then place a piece of sugar in your mouth. Let the saliva moisten your mouth and then put a piece of sugar in your mouth. What differences do you notice in these situations? What is the significance of saliva for the taste buds?"	
Hearing: "One of the peers closes his or her eyes. The pair walks around inside the school and the seeing one gives only oral instructions to walk (i.e. no physical contact). Consider what it is like to perceive a familiar environment on the basis of the mere sense of hearing (and memory). Where are the auditory receptors situated and how do they function?"	
BI	Student pairs present their reports and conduct one exploration for their classmates.
PE+PHY	Physical education was taught jointly with physics in six lessons. Students were given instructions on how to perform specific exercises and why. Before the exercises, they were told that they would model these exercises later and analyse them using digital programs and tools that are commonly used in physics, such as Logger Pro and GeoGebra. The student pairs took photographs and video clips to record their performances and to enable the analysis process.
e.g. Standing long jump: The PE teacher shows how the jump is performed and explains the phases and their significance for performance. The jump is videotaped, and in the next lesson, the PHY teacher advises the students on how to use the computer program to make the trajectory visible and to measure and determine the different phases of the jump.	
PE+PHY	
PE+PHY	
PE+PHY	
PE+PHY	
PE+PHY	
PHI	Lecture about the goodness and evilness of humans according to Mengzi, Paul the Apostle, Socrates, Plato, Aurelius Augustinus, Thomas Hobbes, Rousseau, Immanuel Kant, Nietzsche and Hannah Arendt
PHI	Lecture challenging the ideas of poststructuralism and deconstruction by Jacques Derrida (e.g. impact of language on thinking and valuing, how naming things has affected the ways humans value animals and nature, how humans perceive themselves and whether humans are perceived as animals)
PHI	Lecture about language, how it depicts the world and how powerful words can be. Key question: "Are we all prisoners of language, and are we unable to step outside it to achieve reality cleansed of the effects of language?"
PSY	All three lessons of psychology dealt with humans' higher cognitive processes. The first lesson was a lecture with educational dialogue concerning language processing: speech production and speech comprehension. The topic was combined with the views of philosophy by bringing forth the multimodality and meanings of language. The teacher included the views of biology by going through the structure of the human brain and the different areas of the cortex for different senses. She also narrated the psychological experiments for teaching human language symbols to certain primate individuals. Variations between different languages in different human cultures were discussed.
PSY	Student pairs were tasked to plan and execute a mini-sized psychological study. The teacher provided the student pairs with language-related case descriptions and suggestions on whom to interview. The task was to formulate a research question and hypothesis, to collect and analyse the data, and to discuss the reliability, validity and generalisation of the results. The study reports were published in the Teams Files section.
e.g. Emotional Stroop test: "Use your phone's stopwatch. The emotional Stroop test measures the exact time that elapses between displaying a word in a slide and saying a colour out loud. Write the time on the paper next to each word. Show the slide set to the subject and ask him or her to name aloud the colour that is associated with the word as soon as it appears."	
PSY	Students were introduced to psychological studies dealing with human facial expressions conducted at Tampere University. This was executed as a Teams meeting between the class and the researchers because of the restricted visiting possibilities due to the coronavirus disease 2019 pandemic.
Arts	

Table 1 (*continued*)

	A synthesis of all the views presented by five school subjects was made in arts. During the first arts lesson, the teacher introduced learners to different possible angles of how to approach a joint artwork on the theme "Human being – What am I" and asked learners to formulate questions that resonated with them most.
e.g. Ideas of realisation of the joint artwork: What are humans like? What kind of person am I? Why do we create art? What kind of art do people want to see? Learners discussed their ideas in small groups and were then introduced to different methods of realisation. The researcher asked them to draw concept maps of the concepts they considered the most important in the study unit. After this, learners developed their ideas further. At the end of the lesson, one of the students acted as a secretary and wrote down each small group's ideas on a whiteboard and illustrated the main ideas. Thus, a joint plan was completed.	
Arts	
Arts	Every student participated in the realisation of the artwork (see Appendix D).

Note. BI denotes biology, PE physical education, PHY physics, PHI philosophy and PSY psychology.

narratives are presented in Appendix A and analyzed in section 4.1.

3.4. Course design

Six teachers planned the cross-curricular study unit's timetable, objectives and content with shared themes. They decided not to give a numerical grade for the course but a mark of "approved" or "rejected" to reduce performance pressure.

The upper secondary students in this study applied the inquiry learning model, where they proceeded cyclically by formulating research questions and finding answers. They were introduced to views on humans in the context of biology (senses, taxonomy and evolution, and humans as animals), psychology (higher-order thinking skills), physical education and physics (measuring and modelling exercises), philosophy (naturalism-culturalism and essentialism-existentialism) and arts (joint artwork expressing and exhibiting different views about humans). They were guided to monitor their own learning by setting research questions for themselves, assessing the level of attainment of their learning objectives and writing down the lessons' key concepts in their learning diaries, and pondering key concepts and learning experiences in their portfolios (Appendix B). In this way, the learning process was made more visible, and learners' SRL skills were strengthened.

Inquiry learning took place at two levels: At the first level, students' ongoing task was to write down research questions according to their points of interest in their learning diaries using Microsoft Office OneNote. The teachers responded to these questions by either talking with the student in question or writing to them. Thus, there was an ongoing scientific dialogue over the course of the study unit. At the second level of inquiry learning, each teacher planned the lesson tasks constituting inquiry learning if it was considered possible and useful for learning (Tables 1 and 2).

Three lessons were held in each subject. Physical education and physics lessons were combined and led by two teachers for all six lessons. During the first lesson, the students were given instructions regarding the whole study unit, the researcher informed them about the study, and the procedure of the two-level inquiry learning model with instructions for the learning diary and portfolio was explained to them.

Physical education and physics teachers provided students with questions, methods and solutions before they did the task, thus providing inquiry learning of openness level 1: "confirmation" inquiry learning (Tables 1 and 2; Bell et al., 2005; Herron, 1971; Schwab, 1962). Biology, psychology and arts teachers gave the students questions and methods but let them find solutions themselves (inquiry level 2: "structured inquiry"; see examples of given tasks in Table 1). All tasks involved the students' gathering of data, observations and conclusions. Students constructed explanations of phenomena, tested those explanations and communicated their ideas to others. In philosophy lessons, students were challenged with philosophical questions by engaging them in a teacher-led educational dialogue.

4. Results

4.1. Composite narratives

For MRQ, we first composed narratives of each individual interview by extracting quotations. The second step was to identify the similar themes of these narratives. After analysing each narrative from five viewpoints, namely (1) reaching one's learning objectives, (2) experiences with the learning diary and portfolio, (3) expressing one's SRL skills, (4) the support of different disciplines for each

Table 2
Lessons constituting inquiry learning

Introductory Lesson	Biology	Physical Education + Physics	Philosophy	Psychology	Arts
–	– 2 2	1 1 1 1 1 1	– – –	– 2 2	2 2 2

Note. The numbers denote the level of inquiry learning. – refers to no inquiry learning. (Bell et al., 2005, p. 31)

other and 5) experiences of transitions from one section to another, three narratives were detected and formulated as composite narratives (Appendix A). Most students (six out of 10) felt that they achieved their learning goals well and enjoyed the autonomy of the course assignments (learning diary and portfolio). Thus, this narrative was labelled learning deepened by autonomy. The first of the two counternarratives (expressed by three out of 10 students) identified in the data was labelled struggling with motivation and schedule, and the second (expressed by one out of 10 students) was labelled active communicator with poor effort regulation.

Dominant narrative depicts students who enjoyed making the learning diary and using it as a tool for portfolio writing (Appendix A). The students stayed on schedule the whole study unit, thus expressing good SLR skills of cognition (elaboration, organisation and metacognitive regulation), motivation/affect (relevance enhancement and situational interest enhancement) and behaviour (effort regulation, time and study environment management, and help seeking; Wolters, Pintrich, & Karabenick, 2003).

Some students found the learning diary quite easy but considered portfolio work challenging, thus expressing the first counternarrative (Appendix A). Forming research questions relevant to oneself was perceived as especially difficult. Students fell behind schedule. This demonstrates poor SLR skills at all three levels (cognition, motivation and behaviour) and the need for more support to strengthen those skills.

The second counternarrative depicts a learner who was an active communicator in the lessons but was unable to document their thoughts in the portfolio (Appendix A). The student failed the class because of the lack of a portfolio. When the student tried to report their thoughts in the portfolio, a kind of blockage emerged. The student fell behind schedule. This narrative demonstrates poor self-regulation behaviour skills, especially effort regulation, and the need for more support to strengthen those skills.

Even in such a small group, the differences between students' metacognitive awareness and regulation are vast. Marja, as an example of the dominant narrative, created four main categories at the beginning of the course and narrated that categorising concepts from the course allowed her to understand the concepts of the different subjects better. This was a new learning strategy for her, and she found it highly beneficial. She had already found out that categorising topics by colour supported her learning. Opposite abilities were evident in the cases of Jannika, Katariina (counternarrative 1) and Johanna (counternarrative 2) as they expressed poor SRL skills. Learners' abilities to monitor, reflect and modify their behaviour, metacognition and cognition are SRL skills; they are also referred to as adaptive learning patterns. In other words, students who expressed the dominant narrative showcased both adaptive learning patterns and high SRL skills.

In all narratives, the six school subjects were considered beneficial for the whole study unit. Two students stated that the physical education and physics section was detached from the other sections, and there were too many exercises and too much data collection for the time allotted for going through the results. Thus, it was perceived as messy and confusing. The transitions from one discipline's section to another were regarded as smooth and natural, except for the transition from physical education and physics to philosophy. This transition was described as abrupt by four students. The joint artwork (Appendix D) in the arts section had a significant role for all students because (1) it offered them a means to express themselves and communicate with others and (2) it helped make learning visible and allowed them to compose a synthesis of the different disciplines' viewpoints.

Some students within each composite narrative type regarded the thinking process in itself as the most important thing and recording these thoughts as secondary. Nevertheless, nine of the 10 students found the learning diary and portfolio beneficial in that it made their learning outcomes visible and helped them understand concepts and their relations. Thus, these kinds of self-assessment tools are a good way to carry out inquiry learning.

4.2. Relationship of goal orientation profiles with portfolios and narrative interviews

For SRQ1, we investigated how personal achievement goal orientation profiles related to the level of complexity and depth narrated in the portfolios and qualitative interviews. As expected, on the whole, students had higher scores in the mastery approach than in the performance-approach or performance-avoidance goal orientation (Table 3) because it was a voluntary study unit. The scores varied less between the items of mastery goal orientation than in the two other patterns.

Most students (seven out of 10) expressed a profile of mastery goal orientation (Table 3); they aimed to deepen and broaden their understanding, perceived learning as interesting and expressed an adaptive learning pattern. One student (Mari) expressed a

Table 3
Individual learners' mean scores for personal achievement goal orientation (5-point Likert scale), teachers' assessment of the portfolios (scale of 1–3) and composite narratives (N = 10; names are pseudonyms).

	Mastery approach M (SD)	Performance approach M (SD)	Performance avoidance M (SD)	Portfolio M (SD)	Narrative type
Susanna	4.3 (1.21)	4.4 (0.89)	2.8 (1.33)	2.6 (0.5)	Counter 1
Tiina	3.8 (0.98)	3.4 (1.52)	2.5 (0.55)	1.6 (0.8)	Dominant
Marja	3.5 (1.05)	3.6 (1.14)	1.8 (0.98)	1.5 (0.7)	Dominant
Johanna	4.2 (1.17)	2.2 (0.84)	2.5 (0.84)	-	Counter 2
Leena	4.3 (0.82)	3.8 (1.64)	2.5 (1.05)	2.4 (0.5)	Dominant
Mari	4.0 (1.10)	4.4 (0.89)	1.8 (1.33)	2.8 (0.4)	Dominant
Sofia	4.8 (0.41)	1.8 (1.10)	1.8 (0.75)	1.8 (0.6)	Dominant
Pilvi	4.7 (0.52)	3.8 (0.84)	1.7 (1.63)	1.9 (0.6)	Dominant
Jannika	3.5 (0.55)	2.6 (1.82)	1.5 (0.84)	1.4 (0.5)	Counter 1
Katriina	3.2 (0.75)	2.2 (1.79)	1.5 (0.84)	1.0 (0.0)	Counter 1
Total	4.0 (0.97)	3.2 (1.49)	2.1 (1.08)	1.9 (0.8)	

Note. BI denotes biology, PE physical education, PHY physics, PHI philosophy and PSY psychology.

performance-approach profile; thus, her focus was more on the self and demonstrating her competence to others. This is clearly related to her academic performance as she scored the highest points in portfolio assessment. Two students (Susanna and Marja) expressed a combined emphasis on mastery and performance-approach, but only one of them (Susanna) excelled in portfolio work. No students had a performance-avoidance profile (e.g., focusing on avoiding showing one's incompetence). These results, together with data from the narrative interviews, indicate that all 10 students were likely to possess adaptive learning patterns in an academic learning context.

Table 4

Concepts in the learning diaries, concept maps, portfolios and interviews.

	Concepts in the learning diary	Concepts in the concept map	Portfolio assessment score (1–3)	Links (propositions) to the three most meaningful concepts (excluding the link to the main concept) in the concept map	The most challenging concepts / The most interesting concepts / Threshold concepts, conceptual change, enrichment or belief revision narrated in the interview
Susanna	52	23	2.6	psychology: 5 senses, physical education, philosophy: 4 each	a. mechanoreceptors (BI), PHY concepts b. mind (PSY), good and evil (PHI), BI and PSY concepts c. belief revision: the whole field of philosophy was "confusing"
Tiina	30	26	1.6	biology: 9 physical education + physics: 7 psychology: 4	a. EEG, EMG (PSY), PHY concepts b. BI and PHI concepts c. belief revision: the whole field of philosophy was "strange"
Marja	20	26	1.5	biological side: 9 physical side: 5 mental and spiritual side: 4	a. PHY and PE concepts b. PHI and PSY concepts c. belief revision: the whole field of philosophy was "confusing"; conceptual change: also aha moments in philosophy, felt transition from PE & PHY to PHI as abrupt (suddenly studying questions which have no answers)
Johanna	6	23	-	psychology: 4 philosophy: 3 what is human: 3	a. cognitive processes (PSY), PHY and PE concepts b. existentialism, essentialism, dualism (PHI), cognitive processes and other PSY concepts, BI concepts c. does not narrate any
Leena	52	47	2.4	thinking: 7 senses: 5 needs: 5	a. PHY concepts b. PHI concepts c. enrichment of conceptual constructs in all sections of the study unit; found it annoying that there were many PHI questions left unanswered
Mari	64	103	2.8	mind: 8 ECG: 8 sensory areas of the cortex: 6 scientific research: 6	a. does not narrate any b. PHI, PHY and PE concepts c. does not narrate any; articulates that concepts only help her formulate thoughts in verbal form and that she learned a lot of new concepts
Sofia	51	21	1.8	senses: 6 brain and thoughts: 4 knowledge: 2	a. brawn (muscle strength), energy (PHY), good and evil (PHI) b. PHI concepts c. conceptual change + belief revision: most advanced species (BI, PHI); threshold concepts + conceptual change: fully human – incomplete human (BI, PHI, PSY); cumulative knowledge (BI, PHI)
Pilvi	30	16	1.9	philosophy:4 biology: 3 psychological entity: 3	a. PHY concepts (e.g. mass, weight and acceleration) b. existentialism, essentialism, dualism (PHI); good and evil (PHI) c. threshold concepts + conceptual change: fully human – incomplete human: Can you become human if you are brought up outside the society? (BI, PHI, PSY)
Jannika	36	19	1.4	cognitive processes: 4 concept of human being: 4 consciousness: 2	a. BI and PHY concepts b. existentialism, essentialism (PHI), good and evil (PHI), PSY concepts c. belief revision: the whole field of philosophy was "confusing"
Katriina	11	23	1.0	senses: 5 cognitive processes: 4 concept of human being: 4	a. PHI concepts b. BI and PSY concepts, existentialism, essentialism (PHI), good and evil (PHI) c. belief revision: the whole field of philosophy was "confusing"

The student with a performance-approach profile may have either adaptive or maladaptive learning patterns, but her narrative interview revealed that she possessed excellent SRL skills; hence, her learning pattern can be described as adaptive.

When individual goal orientation patterns were investigated together with the types of composite narratives (Table 3), the findings were as follows: First, the learners with the highest scores in the mastery approach (Sofia, Pilvi, Susanna, Leena, and Mari) narrated either the dominant narrative or counternarrative 1 even though they all should have had adaptive learning patterns with high SRL skills. SRL skills are not a fixed feature in a person (Pintrich, 1999; Wolters, Pintrich, & Karabenick, 2003). For instance, a high number of courses in the same period can result in a decline in effort regulation and motivation and in lagging behind the schedule. Second, the two students with the highest scores in the mastery approach (Sofia and Pilvi) scored poorly in their portfolios. The narrative interviews gave an explanation for this result: These students were so immersed in pondering new ideas that instead of formulating them as text, they preferred discussing these topics with others and letting their own thoughts mature. Furthermore, they did not worry about excelling in the portfolio or other matters related to their studies.

These results are in line with those of previous studies. Both the mastery approach and the performance approach seem to facilitate good academic performance. The performance approach is related to excelling in the short run in written outcomes, and the mastery approach is related to the retention of key concepts and phenomena in the long run (Elliot & McGregor, 1999). Academic performance was strengthened by the absence of a performance-avoidance goal, which has been proven to weaken both types of performance (Elliot & McGregor, 1999).

4.3. Changes in conceptual constructs

We investigated changes in the conceptual constructs in SRQ2 through content analyses of learning diaries, portfolios and concept maps and an analysis of the narratives in the interviews. Mari narrated that all new concepts helped her verbalise her thoughts more accurately than before. Incongruity emerged in her narrative; she first narrated not having learned much but then described how abundantly she had learned new concepts. Her concept map (Appendix E) was the most complex and possessed the most concepts (Table 4). Many students expressed the same kind of inconsistency in their interviews, thus exemplifying how ambiguously upper secondary students are able to reflect on their own learning processes and outcomes. Some students, like Sofia, said that it was difficult for them to put their thoughts into words. Sofia used her cell phone to record good ideas for further modification, while Mari narrated using concepts effortlessly to express her thoughts. Differences in the ability to express one's thoughts were vast between the students.

The data gathered through narrative interviews show that some students did not consider the deepening of their concept perception or the examination of the same phenomenon using the concepts of different disciplines to be relevant (e.g., Susanna). Instead, they would have preferred to learn things that would help them excel in the matriculation exam (e.g., Leena) or enhance their competence in their future profession (e.g., Marja). However, some students (Sofia and Pilvi) identified deepening and broadening their own understanding of humans and humanity as their main objective.

The concept map helped some students (Leena and Mari) make their thinking and concept analyses visible (Appendix E). The only student with a performance-approach orientation (Mari) wrote down more concepts than others in her learning diary and concept map (Table 4) but did not consider learning new concepts or broadening their meanings as learning something new. This is an example of the inconsistency in students' narratives. Another inconsistency is that some students described philosophy as fascinating and interesting in the interview, but its concepts were almost nonexistent and were poorly analysed in the portfolios. Some (six out of 10) students found the whole epistemological and ontological view of the discipline of philosophy confusing or strange and different from all the others because it does not have explicit answers to questions (Table 4). Even though the researcher pointed out that disciplines have different epistemological and ontological views and gave the views of relativism and critical realism as examples, this state of confusion was still evident in the interviews. Nevertheless, the resistance to tackling philosophical dilemmas seemed to lessen after this dialogue took place at the end of the philosophy section. As most of these students found philosophy fascinating and interesting, we regard this confusion as a manifestation of belief revision. However, we were unable to distinguish whether there were some anomalies left in the learners' concept categories.

Physics concepts were identified as the most challenging by nine out of 10 students (Table 4). Some students mentioned having too many exercises and too little time to analyse the physical education and physics phenomena. These results point to a need to lessen the amount of subject matter and give students more time to gain an understanding of the phenomena and their concepts.

Data triangulation suggests that an enrichment of concepts took place in all sections of the study unit even though the narratives were inconsistent. In physics, there was significantly less enrichment; only one student narrated having learned to understand new phenomena or the phenomena in a new way.

Some students (Sofia and Pilvi) vividly narrated how their perception of the world changed when they encountered the concept "fully human", which we regard as a threshold concept (Table 4). Sofia started to ponder what is regarded as fully human and what is incomplete: If a person is blind and deaf or has a developmental disorder, is that person regarded as fully human? In this way, she manifested both a threshold concept and conceptual change when moving concepts across the ontological trees of biology, philosophy and psychology. At the same time, she realised how we use familiar concepts, such as human, without really being aware of their meanings. She also pondered whether "cumulative knowledge" changes the whole human species and what the future might look like, again manifesting a threshold concept as well as conceptual change.

Sofia's narrative is an example of how different learners individually experience meaningful moments in upper secondary education when given stimuli by highly educated teachers. Whole new ways of viewing the world were opened, and she will never see things the same way again. Sofia narrated that she found it extremely fascinating when there were teachers of different subjects present in the lesson and they offered differing views on topics. For example, the philosophy teacher took it for granted that homo sapiens is the

most advanced species, and the biology teacher challenged this by stating that different species are adapted to different environments; hence, some bacteria can be seen as more advanced than humans, as organisms living in hot springs. This made Sofia revise her belief of humans as a species, and there was a conceptual change as she moved the concept with its many attributes from the ontological tree of biology to the ontological tree of philosophy.

5. Discussion and conclusions

The objective of this study was to find out what kinds of narratives upper secondary school students formulate when piloting a cross-curricular study unit with six disciplines. As the school subjects included natural sciences, physical education, humanities, and art, we were especially interested in conceptual changes, whether transitions from one subject to another were perceived as smooth and whether different disciplines were perceived as supporting each other. We also wanted to know whether the learning diary and portfolio could be regarded as beneficial tools for inquiry learning and SRL.

We found that high-quality multimodal parallel data were vital to gathering and understanding the most accurate data possible from individual learners. Quantitative analysis of the PALS questionnaire and content analyses of the learning diaries, portfolios and concept maps provided data that would have been poorly understood without the interviews and their analysis. We found narrative interviews extremely well suited to gathering data from upper secondary school students. Data triangulation provided interesting results that can be applied to teacher training and in-service training for teachers and that support scaling the study unit in question.

According to students' narratives, the pilot study unit succeeded in the two essential requirements of curriculum integration (Jacobs, 1989): (a) there was a clear scope and sequencing with a cognitive taxonomy, thus encouraging thinking skills, and (b) students narrated both discipline-based and interdisciplinary experiences. We found one dominant narrative, which suggests that most students achieved their learning objectives well and applied SRL skills to benefit from the autonomy of the course assignments (learning diary and portfolio), to deepen their thinking and to stay on schedule. On the other hand, some students lacked these SRL skills, thus struggling to calibrate motivation, behaviour and cognition and being unable to stay on schedule.

Three personal achievement goal orientation profiles were found, the most common being the mastery approach. When personal goal orientation profiles were compared to the complexity shown in the concept maps and the depth of thinking shown in the portfolios, we made an interesting discovery: The mastery approach does not relate to the in-depth reasoning in portfolios and concept maps, but it seems to relate to the occurrence of threshold concepts and conceptual change shown in the narrative interviews. This is consistent with previous research (Elliot & Church, 1997; Elliot & McGregor, 1999), which found that the mastery approach does not predict performance outcomes but seems to predict reduction in worry cognitions. Therefore, educators should design cross-curricular study unit assessment in a multimodal way that allows students to showcase their thinking processes and ideas in forms other than writing. This is intertwined with another item included in the curriculum reform: the validity and reliability of assessment. For example, at the end of the study unit, students created a joint artwork, which helped to bring forth ideas that otherwise would have been left invisible and to synthesise different disciplines' views. This is in line with research on connection-building-strength of the visual arts (Scott & Twyman, 2018). As suggested by Hertzberg and Roe (2016), we need more research-based guidance for pedagogical practices to improve upper secondary school students' academic writing skills in various school subjects in the cross-curricular context. Writing or drawing one's ideas and thus elaborating on the subject matter in one's own manner helps students learn better; hence, it is a beneficial SRL skill.

It would be interesting to add a fourth construct, namely the mastery-avoidance goal (Baranik et al., 2010; Elliot & McGregor, 2001), to the trichotomous achievement goal framework applied in this study, especially if investigated with a quasi-experimental design. The mastery-avoidance construct entails the learning profile of a perfectionist who focuses on avoiding a negative possibility, like failing to produce a perfectly organised and illustrated portfolio. This could explain failure in getting the portfolio done.

All but one in the student group narrated that they perceived positive synergy from combining the six subjects with common themes. There was also a spontaneous discussion about the epistemological and ontological differences between the subjects. Some adolescents seemed to reach an in-depth understanding of the essential view in science that beliefs and presuppositions are not true facts but theoretical interpretations which are subject to falsification (Vosniadou, 1994), but many found this confusing and contrary to their ontological and epistemological beliefs. Discontinuities in the narratives may derive from years of studying school subjects within more traditional institutional structures (de Freitas & Bentley, 2012). We encourage teachers to enable students to encounter unfamiliar, educationally critical content of the disciplines ()(Schwartzman, 2010) by carefully selecting common themes for cross-curricular study units to strengthen learners' higher-order thinking skills. While carrying out cross-curricular studies, similarities, differences, and relationships between subjects need to be addressed (Kleve & Penne, 2012) to strengthen students' discipline awareness.

This study suggests that there are adolescents who earn high grades in the academic learning context but cannot see any benefits in learning more concepts or widening their meanings. These students seem to regard only the subject matter useful for excelling in the matriculation exam as relevant. Hence, the matriculation exams or credits required for higher education should take into greater account these cross-curricular study units to raise students' interest in participating in them. Our results indicate that the learning diary and portfolio could be effective in encouraging students to value and strive for deeper thinking skills, and they helped some students open up whole new worldviews. The learning diary helped all the students make their aims, learning outcomes, thinking and concept perception visible; the concept map did the same for some students.

Most students manifested an enrichment of concepts in their interviews, learning diaries or portfolios as they learned more concepts and widened their meanings. Some threshold concepts and conceptual changes were detected. The encounters of some learners with threshold concepts such as "fully human" ignited powerful changes in their mindsets and a whole new worldview. A lot of belief

revision was detected in the philosophy section, but most adolescents failed to describe the concepts in more detail, which can be a sign of defensive responses to unknown conceptual constructs. It would be interesting to investigate these possible anomalies in learners' concept categories further. This result also implies the need for more training in verbal reasoning.

This study shows that learning diaries and portfolios can be used to guide learners to pay more attention to concepts and their importance as tools for thinking. Students can enhance their SRL skills by formulating their personal points of interest as questions in their learning diaries and pondering them further in their portfolios. The findings suggest that it is beneficial for upper secondary students to have opportunities to break subject boundaries, thus strengthening deeper thinking skills and SRL skills and making their learning processes visible. Hence, we suggest a critical approach to cross-curricularity in terms of advocating not the potpourri-like approach of different subjects lacking a clear focus but a well-organised pedagogy, contributing to the tradition of cross-curricular curiosity and proactivity (Dannels & Housley Gaffney, 2009; Jacobs, 1989). It would be interesting to investigate teaching and learning models with cross-curricular approach similar to the one depicted in this study also in other educational levels, such as higher education.

Appendices

Appendix A. The composite narratives.
Appendix B. Guidelines for the learning diary and portfolio.
Appendix C. Narrative interview.
Appendix D. Making the joint artwork.
Appendix E. Concept maps.
Note. Colours are needed for both printable and online versions of the supplemental files "Guidelines for the learning diary and portfolio", "Making the joint artwork" and "Concept maps".

Acknowledgement

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijer.2021.101889.

References

Abbott, H. P. (2008). *Cambridge introduction to narrative* (2nd ed.). Cambridge University Press.

Alexander, P. A. (1995). Superimposing a situation-specific and domain-specific perspective on an account of self-regulated learning. *Educational Psychologist, 30*(4), 189–193.

Armstrong, D., Gosling, A., Weinman, J., & Marteau, T. (1997). The place of inter-rater reliability in qualitative research: An empirical study. *Sociology (Oxford), 31* (3), 597–606. https://doi.org/10.1177/0038038597031003015

Bakhtin, M. M. (1986). *The problem of speech genres. In C. Emerson & M. Holquist (Eds.), Speech genres and other late essays (pp. 60–102). University of Texas Press.Baranik, L. E., Stanley, L. J., Bynum, B. H., & Lance, C. E. (2010). Examining the construct validity of mastery-avoidance achievement goals: A meta-analysis, 23* pp. 265–282). Human Performance. https://doi.org/10.1080/08959285.2010.488463

Baranik, Lisa, E., Stanley, Laura, J., Bynum, Bethany, H., & Lance, Charles, E. (2010). Examining the construct validity of mastery-avoidance achievement goals: A meta-analysis. *Human Performance, 23*(3), 265–282. https://doi.org/10.1080/08959285.2010.488463

Batzli, J. M., Knight, J. K., Hartley, L. M., Maskiewicz, A. C., & Desy, E. A. (2016). Crossing the threshold: Bringing biological variation to the foreground. *Life Sciences Education, 15*(4), 1–7. https://doi.org/10.1187/cbe.15-10-0221

Beane, J. A. (1997). *Curriculum integration: Designing the core of democratic education.* Teachers College Press.

Bell, R. L., Binns, I., & Smetana, L. (2005). Simplifying inquiry instruction. *The Science Teacher, 72*(7), 30–33.

Bell, T., Urhahne, D., Schanze, S., & Ploetzner, R. (2010). Collaborative inquiry learning: Models, tools, and challenges. *International Journal of Science Education, 32* (3), 349–377. https://doi.org/10.1080/09500690802582241

Bereiter, C. (1985). Toward a solution of the learning paradox. *Review of Educational Research, 55*(2), 201–226. https://doi.org/10.3102/00346543055002201

Boekaerts, M. (1995). Self-regulated learning: Bridging the gap between metacognitive and metamotivation theories. *Educational Psychologist, 30*(4), 195–200.

Brown, A. L. (1978). Knowing when, where, and how to remember: A problem of metacognition. In R. Glaser (Ed.), *Advances in instructional psychology 1* (pp. 77–165). Erlbaum.

Chi, M. T. H., & Brem, S. K. (2009). Contrasting Ohlsson's resubsumption theory with Chi's categorical shift theory. *Educational Psychologist, 44*(1), 58–63. https://doi.org/10.1080/00461520802616283

Chi, M. T. H. (1997). Creativity: Shifting across ontological categories flexibly. *In T. B. Ward, S. M. Smith, & J. Vaid (Eds.), Creative thought: An investigation of conceptual structures and processes (pp. 209–234).* American Psychological Association. https://doi.org/10.1037/10227-009

Corno, L. (1995). Comments on Winne: Analytic and systemic research are both needed. *Educational Psychologist, 30*(4), 201–206. https://doi.org/10.1207/s15326985ep3004_5

Cukurova, M., Kent, C., & Luckin, R. (2019). Artificial intelligence and multimodal data in the service of human decision-making: A case study in debate tutoring. *British Journal of Educational Technology, 50*(6), 3032–3046. https://doi.org/10.1111/bjet.12829

Dannels, D. P., & Housley Gaffney, A L (2009). Communication across the curriculum and in the disciplines: A call for scholarly cross-curricular advocacy. *Communication Education, 58*(1), 124–153. https://doi.org/10.1080/03634520802527288

de Freitas, E., & Bentley, S. J. (2012). Material encounters with mathematics: The case for museum based cross-curricular integration. *International Journal of Educational Research, 55*, 36–47. https://doi.org/10.1016/j.ijer.2012.08.003

Duran, M., & Dökme, İ. (2016). The effect of the inquiry-based learning approach on student's critical thinking skills. Eurasia Journal of Mathematics. *Science and Technology Education, 12*(12), 2887–2908. https://doi.org/10.12973/eurasia.2016.02311a

Dweck, C. S. (1986). Motivational processes affecting learning. *American Psychologist, 41*(10), 1040–1048. https://doi.org/10.1037/0003-066X.41.10.1040

Elliot, A. J., & Church, M. A. (1997). A hierarchical model of approach and avoidance achievement motivation. *Journal of Personality and Social Psychology, 72*(1), 218–232. https://doi.org/10.1037/0022-3514.72.1.218

Elliot, A. J., & McGregor, H. A. (2001). A 2 × 2 achievement goal framework. *Journal of Personality and Social Psychology, 80*(3), 501–519. https://doi.org/10.1037/0022-3514.80.3.501

Elliot, A. J., & McGregor, H. A. (1999). Test anxiety and the hierarchical model of approach and avoidance achievement motivation. *Journal of Personality and Social Psychology, 76*(4), 628–644. https://doi.org/10.1037//0022-3514.76.4.628

English, M. C., & Kitsantas, A. (2013). Supporting student self-regulated learning in problem- and project-based learning. Interdisciplinary Journal of Problem-Based Learning, 7(2), 128–150. 10.7771/1541-5015.1339.

Flanagan, M. (2020, March). Threshold concepts: Undergraduate teaching, postgraduate training, professional development and school education: A short introduction and a bibliography from 2003 to 2018. https://www.ee.ucl.ac.uk/~mflanaga/thresholds.html.

Finnish National Agency for Education. Curriculum for general upper secondary schools in a nutshell. 2021 https://www.oph.fi/sites/default/files/documents/curriculum-for-general-upper-secondary-schools-in-a-nutshell-2020_0.pdf.

Fogarty, R. J. (1995). *The mindful school: How to integrate the curricula.* James Bennett Publishers.

Giannakos, M. N., Sharma, K., Pappas, I. O., Kostakos, V., & Velloso, E. (2019). Multimodal data as a means to understand the learning experience. *International Journal of Information Management, 48*, 108–119. https://doi.org/10.1016/j.ijinfomgt.2019.02.003

Guba, E. G., & Lincoln, Y. S (2005). Paradigmatic controversies, contradictions, and emerging confluences. In N. K Denzin, & Y. S Lincoln (Eds.), *The Sage handbook of qualitative research (3rd ed., pp. 191–216). Sage. Kerronnallinen tutkimus. In R. Valli & J. Aaltola (Eds.), Ikkunoita tutkimusmetodeihin 2 [Windows to research methods 2] (pp. 149–167).* PS-Kustannus.

Heikkinen, Hannu (2015). Kerronnallinen tutkimus. In Raine Valli, & Juhani Aaltola (Eds.), *Ikkunoita tutkimusmetodeihin 2 [Windows to research methods 2]* (pp. 149–167). PS-Kustannus.

Herron, M. D. (1971). The nature of scientific enquiry. *School Review, 79*(2), 171–212.

Hertzberg, F., & Roe, A. (2016). Writing in the content areas: A Norwegian case study. *Reading & Writing, 29*(3), 555–576. https://doi.org/10.1007/s11145-015-9607-7

Heywood, D., & Solomon, Y. (2012). Policy, theory and practice in cross-curricularity: What 'problems' does a cross-curricular approach aim to solve? *International Journal of Educational Research, 55*, 1–5. https://doi.org/10.1016/j.ijer.2012.09.001

Hyvärinen, M., & Löyttyniemi, V. (2005). Kerronnallinen haastattelu. In J. Ruusuvuori, & L. Tiittula (Eds.), *Haastattelu: Tutkimus, tilanteet ja vuorovaikutus [Interview: Research, situations and interaction]* (pp. 189–222). Vastapaino.

Jacobs, H. H. (1989). *Interdisciplinary curriculum: Design and implementation.* Association for Supervision and Curriculum Development.

Kleve, B., & Penne, S. (2012). Cross-curricularity in a literacy perspective: Contrast, confrontation and metalinguistic awareness. *International Journal of Educational Research, 55*, 48–56. https://doi.org/10.1016/j.ijer.2012.06.004

Kuisma, Merja (2018). Narratives of inquiry learning in middle school geographic inquiry class. *International Research in Geographical and Environmental Education, 27*(1), 85–98. https://doi.org/10.1080/10382046.2017.1285137

Kuisma, Merja, & Nokelainen, Petri (2018). Effects of progressive inquiry on cognitive and affective learning outcomes in adolescents' geography education. *Frontline Learning Research, 6*(2), 1–19. https://doi.org/10.14786/flr.v6i2.309

Land, R., Meyer, J. H. F., & Baillie, C (2010). Editors' preface:Threshold concepts and transformational learning (Eds.). In J. H. F Meyer, R Land, & C Baillie (Eds.), *Threshold concepts and transformational learning (pp. ix-xliii).* Sense Publishers https://dro.dur.ac.uk/26122/1/26122.pdf.

Le Deist, F. D., & Winterton, J. (2005). What is competence? Human Resource Development International, 8(1), 27–46. 10.1080/1367886042000338227.

Loyens, S. M. M., Magda, J., & Rikers, R. M. J. P. (2008). Self-directed learning in problem-based learning and its relationships with self-regulated learning. *Educational Psychology Review, 20*(4), 411–427. https://doi.org/10.1007/s10648-008-9082-7

Meyer, J. H. F., & Land, R. (2003). Threshold concepts and troublesome knowledge: Linkages to ways of thinking and practising. In C. Rust (Ed.), *Improving student learning: Theory and practice ten years on* (pp. 412–424). Oxford Centre for Staff and Learning Development.

Middleton, M. J., & Midgley, C. (1997). Avoiding the demonstration of lack of ability: An under-explored aspect of goal theory. *Journal of Educational Psychology, 89*(4), 710–718. https://doi.org/10.1037/0022-0663.89.4.710

Midgley, C., Maehr, M., Hruda, L., Anderman, E., Anderman, L., Freeman, K., Gheen, M., Kaplan, A., Kumar, R., Middleton, M., Nelson, J., Roeser, R., & Urdan, T. (2000). *Manual for the patterns of adaptive learning scales (PALS)*. University of Michigan. http://www.umich.edu/~pals/pals/PALS%202000_V13Word97.pdf.

Nikander, P. (2008). Working with transcripts and translated data. *Qualitative Research in Psychology, 5*(3), 225–231. https://doi.org/10.1080/14780880802314346

Novak, J. D. (2010). Learning, creating, and using knowledge. *Concept maps as facilitative tools in schools and corporations* (2nd ed.). Routledge. https://doi.org/10.4324/9780203862001

Novak, J. D., & Cañas, A. J. (2008). The theory underlying concept maps and how to construct and use them (Technical Report IHMC CmapTools 2006-01 Rev 01-2008). Florida Institute for Human and Machine Cognition. https://cmap.ihmc.us/docs/pdf/TheoryUnderlyingConceptMaps.pdf.

Ohlsson, S. (2009). Resubsumption: A possible mechanism for conceptual change and belief revision. *Educational Psychologist, 44*(1), 20–40. https://doi.org/10.1080/00461520802616267

Paavola, S., & Hakkarainen, K. (2005). The knowledge creation metaphor: An emergent epistemological approach to learning. *Science & Education, 14*(6), 535–557. https://doi.org/10.1007/s11191-004-5157-0

Perry, N. E. (2002). Introduction: Using qualitative methods to enrich understandings of self-regulated learning. *Educational Psychologist, 37*(1), 1–4. https://doi.org/10.1207/00461520252828500

Pintrich, P. R. (1999). The role of motivation in promoting and sustaining self-regulated learning. *International Journal of Educational Research, 31*(6), 459–470. https://doi.org/10.1016/S0883-0355(99)00015-4

Pintrich, P. R (2000). The role of goal orientation in self-regulated learning (Eds.). In M Boekaerts, P. R. Pintrich, & M Zeidner (Eds.), *Handbook of self-regulation* (pp. 451–502). Academic Press. https://doi.org/10.1016/B978-012109890-2/50043-3.

Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of Educational Psychology, 95*(4), 667–686. https://doi.org/10.1037/0022-0663.95.4.667

Pulkka, A-T., & Niemivirta, M. (2015). The relationships between adult students' achievement goal orientations, self-defined course goals, course evaluations, and performance. *Journal for Educational Research Online, 7*(3), 28–53. http://hdl.handle.net/10138/233017.

Pulkka, A-T., & Niemivirta, M. (2013). In the eye of the beholder: Do adult students' achievement goal orientation profiles predict their perceptions of instruction and studying? *Studies in Educational Evaluation, 39*(3), 133–143. https://doi.org/10.1016/j.stueduc.2013.06.002

Rosenthal, G. (2003). The healing effects of storytelling: On the conditions of curative storytelling in the context of research and counseling. Qualitative Inquiry, 9(6), 915–933. 10.1177/1077800403254888.

Rosenthal, G. (2004). Biographical research. In C. Seale, G. Gobo, J. F. Gubrium, & D. Silverman (Eds.), *Qualitative research practice* (pp. 48–64). Sage.

Savage, Jonathan (2011). *Cross-curricular teaching and learning in the secondary school (1st ed.)*. Routledge, Article doi:10.4324/9780203844205.

Schwab, J. J (1962). The teaching of science as inquiry (Eds.). In J. J Schwab, & P. F Brandwein (Eds.), *The teaching of science* (pp. 3–103). Harvard University Press.

Schwartzman, L. (2010). Transcending disciplinary boundaries. In J. H. F. Meyer, R. Land, & C. Baillie (Eds.), Threshold concepts and transformational learning (pp. 21–44). Sense Publishers. 10.1163/9789460912078_003.

Scott, T., & Twyman, T. (2018). Considering visual arts practices at the secondary level: Extending cross-curricular conversations among secondary educators. Art Education, 71(2), 16–20. 10.1080/00043125.2018.1414533.

Skaalvik, E. M. (1997). Self-enhancing and self-defeating ego orientation: Relations with task and avoidance orientation, achievement, self-perceptions, and anxiety. *Journal of Educational Psychology, 89*(1), 71–81. https://doi.org/10.1037/0022-0663.89.1.71

Tuominen-Soini, H., Salmela-Aro, K., & Niemivirta, M. (2012). Achievement goal orientations and academic well-being across the transition to upper secondary education. *Learning and Individual Differences, 22*(3), 290–305. https://doi.org/10.1016/j.lindif.2012.01.002

Vosniadou, S. (1994). Capturing and modeling the process of conceptual change. *Learning and instruction, 4*(1), 45–69.

Wengraf, T., & Qualitative research interviewing. (2001). Qualitative Research. *Sage, 19*(4), 471–480. https://doi.org/10.1177/1468794118787711

Willis, Rebecca (2019). The use of composite narratives to present interview findings. *Qualitative Research, 19*(4), 471–480. https://doi.org/10.1177/1468794118787711

Winne, P. H. (1995). Self-regulation is ubiquitous but its forms vary with knowledge. *Educational Psychologist, 30*(4), 223–228. https://doi.org/10.1207/s15326985ep3004_9

Zimmerman, B. J. (1995). Self-regulation involves more than metacognition: A social cognitive perspective. *Educational Psychologist, 30*(4), 217–221. https://doi.org/10.1207/s15326985ep3004_8

Wolters, C. A., Pintrich, P. R., & Karabenick, S. A (2003). Assessing academic self-regulated learning [Paper presentation]. Conference on Indicators of Positive Development: Definitions, Measures, and Prospective Validity. Bethesda, MD: ChildTrends. http://www.childtrends.org/wp-content/uploads/2013/05/Child_Trends-2003_03_12_PD_PDConfWPK.pdf. *Educational Psychologist, 33*, 73–86. https://doi.org/10.1080/00461520.1998.9653292, 2-3.

Zimmerman, Barry, J. (1998). Academic studying and the development of personal skill: A self-regulatory perspective. *Educational Psychologist, 33*(2–3), 73–86. https://doi.org/10.1080/00461520.1998.9653292

Zimmerman, B. J. (1990). Self-regulated learning and academic achievement: An overview. *Educational Psychologist, 25*(1), 3–17. https://doi.org/10.1207/s15326985ep2501_2