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Critical events in the development of scientific thinking among communication and journalism students

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Abstract

University studies represent large, overarching changes in students' epistemological beliefs and thinking skills. Scientific thinking skills are crucial for communication and journalism (CJ) students and graduates. However, the development of CJ students' thinking remains relatively unexplored. The aim of this study was to understand students' perceptions of the characteristics and significance of critical events in the development of scientific thinking in CJ university education. We employed interview data (N=34) from students in two Finnish universities. In a qualitative critical event analysis, we identified four types of critical events in the five-year education of the students; (a) first times, (b) learning hands-on and gaining agency, (c) thinking together, and (d) working hard and overcoming challenges. The development of scientific thinking through critical events was experienced by the students as epistemological change and strengthened competence as a future academic expert. Altogether, our results shed light on thinking development as a tumultuous process in communication education, and how this process relates to students' emerging professional expertise. We discuss both the theoretical and pedagogical implications of our findings to communication education–especially the importance of challenging students in scientific thinking, offering early research-oriented teaching, and acknowledging the overarching role of scientific thinking throughout the curriculum.

KEYWORDS: communication studies, critical events, journalism studies, scientific thinking, university education, qualitative research

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The years that students spend at university bring about growth and change. The entire university experience represents several big life changes: transitioning from adolescence into adulthood, joining new communities, gaining new competencies, taking new perspectives, and so forth. It is also a time of change, even turbulence, in students' thinking and epistemic beliefs (Bendixen, 2002). During their studies, students undergo a variety of changes in their ideas of the nature of knowledge and knowing, and the ways in which knowledge is produced, as they develop a scientific way of thinking (Murtonen & Salmento, 2019). These changes can be fostered by several factors and events in their academic life: the instruction in which they participate, the academic communities they join, and everyday communication within different social settings. Relationships, courses, disciplines, and even entire universities may represent influential contexts for developing one's thinking.

In the present study, we examine communication[1] and journalism (from here on, CJ) students' perceptions of critical events and their significance in the development of scientific thinking in their university education. Scientific thinking skills, such as critical thinking, research skills, and epistemic maturity, are essential to the expertise that all university graduates need in society (Murtonen & Salmento, 2019), and arguably important also for CJ graduates. CJ graduates will be employed in various positions as knowledge professionals (e.g., Donsbach, 2014) who create and negotiate meaning, and share information within different contexts. They will take part in communicating and making sense of societal decision making and in shaping communities' and audiences' understanding of various issues. In the present age of

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[1] For clarity, we use the term 'communication' in this text to refer to teaching and studying in university programs of communication studies, which were formerly known as speech communication programs in Finnish universities.

many societal uncertainties, wicked problems, increasing influence of AI (Bowen, 2024), and issues related to dis- and misinformation, students must develop research skills and criticality (Zou et al., 2023), but also the ability to be adaptable and maintain ethical judgment. Despite both enduring and recent needs for thinking skills, the scientific thinking of CJ students remains largely understudied.

CJ graduates must be able to interpret research-based knowledge, discern it from other types of knowledge, and communicate it to others. However, sufficient knowledge and thinking structures do not necessarily form during university studies. A recent qualitative examination indicates that journalism students' engagement with disciplinary content knowledge can be sporadic and incoherent, and more applied than research-intensive (Ripatti-Torniainen & Mikkola, 2022). This is worrying, as for CJ students, scientific thinking skills, such as evidence-based reasoning and understanding of the contextuality of knowledge (Murtonen & Salmento, 2019), can be seen as an integral part of their professional expertise. It is important that educators know and understand how and where scientific thinking skills develop–or do not develop–throughout CJ studies, as well as how to support this development. To ensure that CJ education equips students with the skills needed to navigate a complex and fast-changing societal landscape, we need to first better understand how these skills are perceived by students and how their development can be supported in education.

The development of scientific thinking

Early definitions of scientific thinking focused on the development of causal reasoning in children in tasks related to natural sciences (e.g., Piaget, 1971); later, skills needed in the entire scientific process–inquiry, analysis, inference, and argument–were integrated into definitions (Kuhn, 2010). In this study, we adopt Murtonen and Salmento's (2019) broad conceptualization of scientific thinking in higher education, which builds on theories that emphasize not only causal inference, but also epistemic maturity and argumentation (e.g., Kuhn, 2010). Murtonen and Salmento (2019) define scientific thinking as a general, higher-order thinking skill that consists of five components: critical thinking, epistemic maturity, research skills, evidence-based reasoning, and a contextual understanding of knowledge. Among these components, critical thinking and research skills have been most frequently discussed in the literature on CJ education (e.g., Ruminski, 2006; Parks et al., 2011).

Critical thinking–the ability to analyze and evaluate information and arguments in a reflective manner (e.g., Aston, 2023)–is arguably at the heart of both communication and journalism education. Activities common to communication education, such as group problem-solving and debate, are usually seen as fostering critical thinking, and the rhetorical foundation of communication is closely tied to reasoning; however, systematic definitions and empirical research of critical thinking development in communication education have been lacking (Ruminski, 2006). Literature mainly focuses on pedagogical activities to enhance students' thinking, such as creative real-life problem-solving exercises (e.g., Tallent & Crowley, 2012). While critical thinking is often seen as developing throughout CJ curricula, research skills are commonly explicitly addressed in research methods courses (Parks et al., 2011). Consistent exposure to research-related tasks and materials throughout studies has been shown to be beneficial for skill development (Wilmore & Willison, 2016). However, both communication (Parks et al., 2011) and journalism (Bowe et al., 2020) scholars have critiqued programs for addressing research skills only in methods courses that mostly occur quite late, and for failing to integrate research skills into the rest of the curriculum.

Overall, our understanding of CJ students' scientific thinking and its development, especially from a broader standpoint, is limited. For example, the maturation of epistemological beliefs–a person's beliefs about the nature and origins of knowledge and knowing (e.g., King & Kitchener, 1994)–can be regarded as a cornerstone of scientific thinking (Salmento & Murtonen, 2019); yet research on CJ students' epistemological development is insufficient. Personal epistemologies are commonly approached as developing through phases (e.g., King & Kitchener, 1994). Thus, as they develop, a more sophisticated and relativistic understanding of knowledge is created: one where knowledge is regarded as uncertain, complex, and developing, as opposed to fixed, certain, and dichotomous (Hofer & Pintrich, 1997). From a constructivist developmental perspective, a similar gradual process occurs in relation to all thinking, as learning is seen to occur through critical self-reflection on one's beliefs and understandings, leading to the transformation of old frames of reference (Mezirow, 2018). In CJ education, it seems crucial that students learn to recognize the epistemological foundations of knowledge, as they themselves will become professionals who partake in creating and sharing knowledge.

It is commonly assumed that for epistemological development to happen, some sort of experience of disequilibrium or cognitive conflict needs to occur (Hofer, 2004). Bendixen's (2002) process model of epistemic belief change illustrates the role that doubt plays in epistemic belief change. Epistemic doubt, in which a person begins doubting their previous beliefs, is triggered by independence and exposure to new ideas (Bendixen, 2002). This may provoke anxiety or confusion about what or whom to believe–such dissonance is important for change to occur (Bendixen & Rule, 2010). What follows, is a "struggle forward," as an individual pursues new and better-suited beliefs and gains control of them through individual reflection and social interaction (Bendixen, 2002). Higher education can function both as a site for triggering epistemic doubt as well as discovering new beliefs both through individual reflection and social interaction offered in studies (e.g., Rosman & Kerwer, 2022).

Critical events in the development of thinking

One lens for understanding the development of scientific thinking in education is to examine critical events, where epistemic doubt, change, and learning can take place. A critical event refers to an incident, occurrence, or experience that has had a significant impact on an individual's perceptions, attitudes, or even worldview (Mertova & Webster, 2009), often causing them to adapt their previous operating strategies (Webster & Mertova, 2007). An event becomes critical when meaning related to its significance is, usually in retrospect, attached to it (Gilstrap & Dupree, 2008). Although critical events related to content learning in higher education have been widely studied (e.g., Pott, 2015), fewer studies have focused on the unplanned, naturally occurring critical events that foster thinking skill development during university studies. Examining students' accounts of critical learning events has been considered a valuable approach to gathering evidence of thinking development (Hofer, 2004; Hofer & Pintrich, 1997). An example of such an approach can be found in Lee's (2018) qualitative examination of critical incidents experienced by university students in Hong Kong, in which the entire college transition was found to be a meaningful critical event for epistemic belief change. However, more nuanced knowledge is needed about where and how the development of thinking is experienced.

Critical events are generally regarded as important for transformative learning, in which the challenge of existing habits brings about change and new perspectives (Christie et al., 2015). Teachers can direct students' focus to critical events by guiding them to recognize their thoughts, emotions, and behavior in key moments of learning (Lindh & Thorgren, 2016). Bendixen (2002) and Lee (2018) have recommended triggering epistemic change by provoking dissatisfaction with current knowledge, offering multiple perspectives, and providing students with support in the possibly tumultuous process of embracing new ways of thinking. Reflective discussions and writing, as well as group work, can also foster critical events and learning (Gilstrap & Dupree, 2008). Problem-based learning is also advocated in relation to scientific thinking development because it fosters metacognitive development and agency (Murtonen & Salmento, 2019).

In summary, the scientific thinking skills of CJ students are an understudied area. In the current age of various challenges and uncertainties related to knowledge and information, it is more important than ever that we further our understanding of thinking skills and the experiences that are perceived as significant for their development. This will also allow educators to better support CJ students' development into professionals who can tackle modern day challenges. Researchers have also pointed out that there is a need for qualitative examinations of how the actual change processes related to thinking in university studies are experienced and interpreted (Bendixen, 2002; Lee, 2018). It is also crucial to examine how instructional practices influence experiences of thinking development, and how students interpret the complex and possibly tumultuous processes (Hofer, 2004).

The aim of this study is to understand the characteristics and significance of critical events that CJ students recount when reflecting on their university education. Through our examination, we aim to offer insights into how to enhance and support the development of scientific thinking in CJ education. We pose the following research questions:

RQ1: What are the characteristics of critical events that CJ students relate to the development of their scientific thinking?

RQ2: What kind of development in scientific thinking do the students attribute to their experienced critical events?

Methods

Data collection

We explored the development of scientific thinking in the context of CJ education at two Finnish universities. The communication programs offered in these universities focus on social interaction, with the curricula entailing areas such as interpersonal and small group communication, communication competence, political communication, and public speaking. Journalism programs aim to build one's understanding of how societal knowledge and views are constructed and how they are brought into public discussion. The studies entail, for example, content of media representations and their critical evaluation, journalism ethics, and practical professional skills for multimedia journalism. In both universities involved in this study, the BA programs overlap: students take basic courses in both communication and journalism as well as joint research courses. Most CJ students do both their BA and MA degrees in the same study program as is customary in Finland. The expected length of studies in Finland is 3 years for BA studies, and 2 years for MA studies. Students from both programs usually graduate with an MA degree.

The data was gathered as part of a larger research project examining the development of scientific thinking in the Finnish university education of communication sciences. In this paper, we employed interview data gathered from CJ students at two Finnish universities. These students were currently writing or had just finished writing their bachelor's (mainly third-year students) or master's thesis (mainly fifth-year students). Students currently participating in thesis seminars (approx. 25 to 40 students per seminar) were invited via email sent by their thesis seminar instructor to participate in individual research interviews. The first author conducted the interviews in Finnish. The interviews were recorded and transcribed verbatim.

In the process of data collection, we followed the principles for research with human participants laid out by the Finnish National Board on Research Integrity TENK (2023). The integrity, autonomy and anonymity of research participants was respected. All recruited participants were volunteers, and it was emphasized that participation would not have any impact on the students' grades or studies in any way. All participants were offered information about the purposes of the research project. We received written consent from all participants.

A semi-structured thematic interview scheme (e.g., Cramer, 2017) was developed for the overarching project. The scheme dealt with themes of academic self-efficacy beliefs, importance of scientific thinking in working life, motivation for university studies, personal epistemology, knowledge and its relation to one's studies, scientific thinking and its development, and sources of knowledge and one's relation to producing it. For the purposes of the present study, sections of the interview data that addressed the sixth theme were used. Within this theme, students were asked to think back to their studies and identify events that they saw as relevant or memorable to the development of their scientific thinking. They were then encouraged to describe the event with questions, such as the following: Who was in this situation? What course was this? What did you do? What did you do after that? Why do you think this event is memorable to you? Do you ever think back on this experience? How has it changed your thinking? (see Anderson et al., 2020, for a similar protocol). No predetermined definition of scientific thinking was given to the interviewees; rather, they were encouraged to reflect on their own understanding of the concept.

Altogether, 14 of the interviewees were journalism students (6 BA and 8 MA students) and 20 communication students (9 BA and 11 MA students). In the analysis, the interviewees are referred to with an individual code, e.g., JBA1, which refers to their study major (journalism), level of study (BA) and number in that interview group. The interviews produced 54 hours and 50 minutes of recorded data. The average duration of the interviews was 1 hour and 28 minutes. Altogether, the interviews resulted in

616 pages (font size pt. 12) of transcripts. For our analysis, the initial dataset was reduced to excerpts related to the sixth theme. In addition, the entire dataset was read through to identify other parts of the interviews in which the interviewees described critical events in sufficient detail. This step narrowed the initial dataset to 45 pages of transcribed data (18,601 words).

Data analysis

Researchers analyzing critical incidents have labelled their analysis as critical incident technique (CIT) (Flanagan, 1954; Gremler, 2004), critical incident analysis (Montgomery et al., 2021), and critical event analysis (Webster & Mertova, 2007). Common to these methods is a thematic, qualitative analysis of people's accounts of events or incidents that they identify as significant for an activity or experience (see Simmons, 2017)—such is also the case in the current study. Thematic analysis provides a rich and nuanced interpretation of the data, allowing for the examination of both manifest and latent content through the analysis of themes (e.g., Vaismoradi & Snellgrove, 2019).

Our aim was to begin with an objective look into students' accounts of critical events and then proceed into more interpretive analysis of the meanings and essence of these experiences and their perceived consequences. Through this process, the aim was to eventually produce an understanding of the self-perceived development of scientific thinking. The first and second authors first coded the data both separately and together. Our unit of analysis was a critical event and its described situational and contextual factors and consequences. We approached critical events as accounts of memorable or unexpected experiences that have affected the individual's perception of their worldview, performance, or functioning (Webster & Mertova, 2007).

After narrowing the overall interview data of the research project to the extracts relevant to this study, the data set was read through to identify accounts of students' memorable or unexpected experiences related to scientific thinking. Altogether, 63 individual accounts were identified in the data, ranging from memorable single comments by lecturers to the entire basic studies or the bachelor's thesis process. After reading through the accounts several times, we began data-driven coding of their situational and contextual features, as well as perceived effects, as is typical of studies of critical events (e.g., Simmons, 2017).

We coded the events according to the phase of studies they occurred in and the context of the event, such as in class, outside formal teaching, being alone or with others. We also coded the thoughts, feelings, and learning experiences students related to the events. During this phase, we identified several similarities and overlaps in the situational features of the original 63 accounts (e.g., several similarly described experiences related to study circles, or thesis processes), and thus consolidated the individual accounts into 21 distinctively different critical events. This phase in the analysis produced a preliminary categorization of the characteristics of the events and their perceived outcomes on thinking. These categories were then contrasted and compared to identify recurring types of experiences evident in critical events, as well as overarching themes related to the perceived impact these events had had on students' thinking. Differentiating the types of events from their perceived outcomes in thinking proved challenging at times and required critical discussions between the coders.

The analysis occurred in several phases, during which we compared and critically discussed codes and notes, critically discussed the first findings, merged initial descriptive codes into categories, and finally created more interpretive themes representing our main findings: the types of critical events and the perceived outcomes of critical events on thinking.

Findings

Altogether, our findings give insight into both the characteristics of critical events, as well as the self-perceived significance of critical events for scientific thinking. Next, we will introduce our findings, beginning with the four types of critical events: *first times, learning hands-on and gaining agency, thinking together*, and *working hard and overcoming challenges*. The types, their occurrence during studies, and the specific events are presented in Table 1. The data extracts presented were semantically translated from Finnish to English by the first author.

Types of critical events associated with scientific thinking

First times

The first type of critical events was *first times* experiencing, learning, or trying something important related to scientific thinking. While, as such, there is a "first time" for all experiences, the interviewees identified specific first times that were meaningful for their thinking. Overall, the students connected their experiences of critical events to the bachelor stage of their studies, often either to the beginning of studies or to the BA thesis project. This pertained also to those doing their MA thesis at the time of the interviews. A typical critical event was described as the first time the student had experienced, realized, learned, tried, or understood something important related to their field, which could occur even in the very first lectures:

> What comes to mind are those very first mass lectures in communication, where we went through the basic concepts, and there was like a percentage, something like, 'this is how much of what we listen to gets lost,' or something. These moments like, aha, really, and this has stuck with me, just like, what is listening, what does active listening entail? (CBA10)

The BA thesis, which is mostly done in the third year of study, stood out in the students' accounts as an important first experience of conducting research. Many interviewees also reflected on it being the first time they had experienced having their thinking abilities challenged: "That [BA thesis] was the first time when I had to really think, and it was probably the first time that I was challenged" (JMA5).

Some of the interviewees expressed surprise at their first critical events occurring late—even too late—for their thinking to develop and mature. They even referred to being "on autopilot" (JMA7) for the entire BA studies, end experiencing encouragement for independent thinking only in their masters' studies:

> Only in the master's studies were we encouraged to use our own brains and to think. In this sense, learning scientific thinking and being guided toward it happens for quite a short period of our five-year studies. I mean, if we only get to use our own brains during the last two years. (JMA7)

Table 1. Types of critical events and their occurrence during studies

Type of critical event	Content of studies	Specific events
First times	Courses in major studies	Lecturer comments Basic studies Research-oriented studies Last MA degree courses
	BA thesis	Challenging one's thinking in the thesis process Research process phases and tasks
Learning "hands-on" and gaining agency	MA thesis	Drawing conclusions Immersing oneself in the research topic
	BA thesis	Research process phases and tasks Applying theory into research
	Courses in major studies	Applied courses Project-based learning experiences
Thinking together	Courses in major studies	Study circles Classroom exercises Informal discussions Group projects and discussions
	BA thesis	Thesis seminars Discussions with supervisor
	Multidisciplinary courses	Group projects and discussions
	International exchange	Informal discussions
Working hard and overcoming challenges	Courses in major studies	Extensive reading and writing Lecturer comments Single reading materials
	BA Thesis	Managing uncertainty Organizing materials and ideals

Learning hands-on and gaining agency in scientific thinking

The second type of critical events that we identified was *learning hands-on and gaining agency in scientific thinking*. The interviewees discussed gaining a "hands-on" perspective on university studies and the disciplinary content, learning by doing, and, in that process, experiencing a sense of agency related to thinking. The interviewees reported seeing the bachelor's thesis process as especially important for the development of thinking through hands-on learning. The specific phases and tasks of the thesis process, such as interviewing, analyzing data, and drawing conclusions were emphasized as significant for understanding the procedures and practices of research. The students identified realizing both how to apply existing knowledge in the research process, as well as how to derive new ideas, through these events:

> The first thing that comes to mind is this whole bachelor's thesis process and how much it has developed me; the very thought of what the research process is made of and what kind of ideas we can derive from it. (CBA6)

The thesis projects, along with the many tasks and decisions related to them, were also important for the interviewees' described sense of agency. The MA thesis was mentioned as critical for this experience. The interviewees referred to the MA thesis and immersing themselves in their topic as beneficial for *themselves,* their own thinking and overall academic competence: "I realized I can examine issues that I am personally interested in. I don't have to do this for anyone other than myself. Of course it's a thesis, but mostly it exists to serve me." (JMA4)

CJ studies encompass various project courses, exercises, and internships, providing opportunities for practical, hands-on learning, and applying theories into practice. This was described as important for developing a sense of agency: "This [MA level project course] has shown me what this field I'm studying can be in practice. It's been really important because everything I learn here, I take with me to my working life" (CMA1). Such critical events were seen as enabling an understanding of one's capabilities and the practical implications of their education, highlighting the connection between academic learning and professional application–essentially, what one can do with one's education.

Thinking together

The third type of critical events we identified was *thinking together*. These events occurred in various collaborative learning situations: group tasks, projects, informal discussions, reading circles, critical discussions, and course exercises like presentations and feedback sessions. Multidisciplinary courses and international exchange experiences were also highlighted. These collaborative events appeared meaningful for gaining new perspectives and ideas from others. They were described by the students as sites for developing one's communication competence, self-expression, writing, and research skills with others. The interviewees particularly recalled study circles as helpful for internalizing theories by verbalizing learning processes in discussion with others:

> One [event] that very strongly comes to mind is from this course on foundational theories where we had a study circle, each of us read about a theory and had to explain it to others...I had to internalize it first and then share with others. Maybe this sort of internalization is what brings about scientific thinking….The course was very good from the perspective of sharing scientific knowledge with peers. (CMA1)

A journalism student shares another experience of a study circle, highlighting the dialogical nature of discussing theories with others and gaining new perspectives:

> We went through a lot of journalism literature and then gathered for study circles. It really developed my own thinking when I had to discuss with others for like an hour, with three other people, and somehow, I got so many new thoughts on top of my own thinking, and that really developed it…. this interactive way, I got to hear what others got out if it and we could compare, compare our own thoughts I guess... and exchange experiences (JBA1)

Experiences of thinking together also occurred in situations where students had observed others' experiences and reflected on them together. They occurred both in the classroom and in informal discussions outside the classroom: before and after lectures, during lunches, et cetera. A student interviewed during the covid-19 pandemic remembered such informal discussions as especially meaningful:

> Back when we could still hang out on campus... the discussions we had after classes with other students, reflecting on things we learned like, 'Hey, you know, if we thought of this situation that occurred yesterday like this'—these are the moments I reflect on. (CMA6)

Working hard and overcoming challenges

The fourth type of critical events related to the perceived development of scientific thinking is *working hard and overcoming challenges*. Prominent single events mentioned by the interviewees were reading and writing tasks, often related to theory-intensive courses. The importance of working intensely, and often independently, was emphasized in the students' accounts. These experiences were even referred to as "shocking," or "insane amounts of reading." A journalism student reflects on being required to summarize a lot of reading, which had led to newfound ways of thinking:

> Having to write, summarize and then draw one's own conclusions, I started seeing connections between things, which I think is important for scientific thinking. It was really important that I *had* to write, not just take part in an exam full of trivia. (JBA2)

Another key experience of working hard that was reflected on was working on one's own thesis both at the end of the BA and MA studies. Doing one's thesis—a small-scale research project—was naturally perceived as a big and challenging process that entailed many significant events for the interviewees. Especially the BA thesis process entailed experiences of hard work, demanding perseverance, dealing with uncertainty, and significant effort to organize one's own thinking:

> You realize, 'oh man, I have to organize my thoughts so much, I've never had to organize my thinking this much, I have so many ideas, and I have so many things that I need to put on paper,' and you have to do such an enormous amount of work inside your own head for the knowledge to, come out the way you want it to. (CBA9)

While many challenging events were related to extensive tasks or projects, some students also reflected on seemingly small events, such as memorable comments by lecturers, or smaller reading tasks, that had led them to experience discomfort or an imbalance regarding their habitual ways of thinking. Balancing this disequilibrium was perceived as requiring a lot of hard work and reflection. A student already working as a journalist reflected on reading a research article that had resulted in recurring reflection and questioning of one's thinking:

> I remember this study that said...that journalists have a hard time recognizing their own power and that they deny this power, and I was like, 'It's not like this at all, of course they recognize it; this issue is constantly discussed,' and afterwards, I've come back to this idea many times and seen that in some instances, it was true....but then again, I wouldn't make it through my workday if I were constantly thinking about (laughs) all the power I have....I'd like to constantly argue that study but also admit that it was true. (JBA6)

Development of scientific thinking through critical events

Our analysis highlights two central outcomes of the self-perceived development of scientific thinking brought about by critical events. The first theme involves change and development in personal epistemologies. The second theme involves strengthening students' sense of competence as future academic experts. These outcomes and their manifestations are detailed in Table 2.

Epistemological change and development

As the students noted, critical events had made them aware of their personal epistemologies—their beliefs about knowledge and knowing. The students also identified several changes in these beliefs over the course of their studies. The accounts of critical events that we collected all point to an epistemological change and development.

According to the students, critical events had led them to identify a nuanced understanding of the multifaceted nature of knowledge. They reported developing an appreciation of how various communicative and social phenomena can be approached from diverse personal, theoretical, and methodological perspectives. This understanding emerged, in their view, from challenging one's thinking both in major and minor studies. In addition, thinking together, especially in group work, had brought about an awareness of various subjectivities related to knowledge and meaning. As a result, the students described learning to see knowledge not as stable and unchanging, but as relative, contextual, subject to change, and requiring a critical approach. A student describes understanding how theories can be applied or understood in various ways:

> An aha moment like, wow, you can look at this issue from this perspective, also realizing that my group member might look at this phenomenon in this way, even if it is the same theory we are looking at, you can, there are so many ways of looking at it. (CBA2)

Critical events, especially those related to hands-on learning in the thesis process, were also described as sparking deeper understanding of the process of conducting research and producing new knowledge. As a result, the interviewees discussed being able to better identify the scope and level of their own research skills. The students discussed development in their skills of information searching, analyzing

Table 2. Development of scientific thinking through critical events

Development theme	Manifestation in thinking
Epistemological change and development	Understanding the multifaceted nature of knowledge Understanding the contextual and relative nature of knowledge Understanding the process and skills of knowledge creation
Strengthened competence as a future academic expert	Integration of scientific and field-specific professional knowledge Emerging expert identity in one's field and professional community

and structuring knowledge, controlling the research process, and understanding their own thinking. For some, writing represented a key route for understanding research. Collaborative research-related processes—whether occurring in seminars, project work, or outside the classroom—were also highlighted as impactful for understanding knowledge production.

Whether occurring in individual writing tasks or collaborative processes, an important change, according to the students, was a shift from learning or even memorizing research results to understanding research processes:

> When I'm studying for a test, what I'm actually doing is learning research results, not how research is done. I'm learning to know the things. This [BA thesis] is the first thing that has taught me an actual understanding of, for example, what is referencing other studies and why we do it. (JBA6)

Strengthened competence as a future academic expert

The second main outcome of critical events that the students brought up was the self-perceived integration of scientific and field-specific professional knowledge, contributing to the development of an emerging expert identity within one's field and professional community. Over time, these critical events seemed to make research and scientific argumentation central to what the students perceived as the expertise of an academically trained communication professional or journalist. The events that were described as bringing about this change were primarily related to hard work, overcoming challenges, and hands-on learning.

The students described forming a scientific worldview in their studies: a realization that different societal phenomena can be approached via scientific thinking and with scientific evidence. This had given the interviewees tools to use both during and after their studies. They also highlighted the applicability of research-based knowledge in argumentation, but also for observing, analyzing, and developing human communication:

> I would be outside looking at a communication situation and then I would start to think like 'Does this one theory I've learned apply to this situation'—I think this is related to finally internalizing how our theories manifest in practice. (CMA9).

Throughout their studies and critical events, the interviewees reported developing an emerging identity as future experts. This identity was seen as shaped not only by personal growth experiences but also by a critical understanding and evaluation of their field. The students described learning to trust their own competence and ability to apply disciplinary knowledge in practice as a crucial part of this process. One journalism student reflected on a radio project as enhancing both their professional identity and their ability to work with knowledge:

> I learned to trust myself a little, that my journalistic views are somewhat valid...I think finding one's identity is such a big part of this profession; you have to write a lot of stuff in a sort of deteriorating state of mind where you constantly doubt your professional skills. (JBA3)

Similarly, a communication student reflected on a project course in which their sense of disciplinary competence and identity were strengthened by a comment coming from a professional from a different field:

> We designed a communication training for engineering students...they held pitches and we gave them feedback...they were like, in awe of our com-

> petence.... When someone from another scientific community says, 'Wow, it's so great to get comments from an expert', you're just like, 'Ha, I'm an expert, wow!' (CMA8)

The students' reflections on growing into a realization of one's own emerging professional identity also entailed experiences of looking at one's own field in a new way. This might mean a criticality towards one's own profession, as discussed by a journalism student: "My own ideas about this field changed a lot...for example, how male centered the ideals of journalism are. That was a totally new perspective for me, and I've thought about it a lot since" (JBA1).

Several communication students discussed looking at their studies and the field of communication in a new way at the very last stages of their studies:

> All of these final courses have been more like, looking at the field of communication as a whole—where it is going, if we look at it from this perspective, looking at all of these things and situations, maybe this has developed, somehow, still raised the level of my thinking (CMA6).

Discussion and conclusions

The aim of the current study was to understand the characteristics and significance of critical events in students' self-perceived development of scientific thinking within CJ university education. Our analysis identified four types of critical events that were experienced by the students as contributing to the development of their scientific thinking: working hard and overcoming challenges, first times, thinking together, and learning hands-on and gaining agency. The identified critical events were described as leading to two key outcomes in the students' thinking: epistemological change and development, and a strengthened competence as a future academic expert. Overall, it seems that CJ students experience a variety of events throughout their studies that may become critical in the development of their scientific thinking, seen broadly as epistemic maturity, critical thinking, research skills, reasoning skills, and contextual understanding of research (Murtonen & Salmento, 2019). We will now discuss our findings, their pedagogical implications for the university education of communication sciences, as well as limitations and future directions for research.

Transformations in students' thinking and knowing

Our findings on the development of CJ students' scientific thinking skills, particularly those regarding epistemic maturity and critical thinking, support the notion that epistemic belief change is a tumultuous process (e.g., Bendixen & Rule, 2010). This process involves experiences of dissatisfaction with previous knowledge, doubts about the nature of knowledge and thinking, and self-doubt about one's capabilities, as well as the discovery of new ways of thinking and knowing. Our findings highlight experiences of working hard and having one's thinking challenged as playing a significant role in altering and developing students' epistemological beliefs and thinking. Challenges are an important part of university education and epistemological development (Bendixen, 2002) and should not be avoided, but rather encouraged in instruction, to enhance the development of students' scientific thinking skills.

Several critical events that we have identified are connected to first times: first lectures, courses, research experiences, and so forth. The very first experiences related to scientific thinking—some occurring during the first days of university studies—might be meaningful and continue to shape students' thinking even years after their occurrence. These firsts of trying, understanding, and learning something are meaningful triggers for epistemic doubt and belief change. Even the interviewed MA students highlighted early experiences or the bachelor's thesis as central to their thinking development. This emphasis on first times is understandable both from the viewpoint of scientific thinking and critical events. The beginning of university studies usually significantly alters and challenges students' sense of self, social identity, and epistemic beliefs (Hofer, 2004), and it has been identified as a key critical incident for epistemological development (Lee, 2018). Furthermore, temporal distance is generally regarded as relevant for an event to become critical for and individual (Webster & Mertova, 2007).

A central reported transformation in CJ students' thinking seems to be a shift from being a passive consumer of knowledge to an active, critical evaluator and producer of knowledge in collaboration with others. This change seems to be particularly evident during the BA thesis process, which was perceived as a significant first-time experience for the students. Overall, the BA thesis represents a crucial moment in CJ education, combining all types of critical events—hard work, new experiences, collaborative thinking, and gaining a hands-on perspective to knowledge—resulting in what has been called "powerful knowledge" (Harland & Wald, 2018). Thinking thus becomes something that students are or do, rather than something they passively have (Aston, 2023). This is akin to Barnett's (2009) influential suggestion that higher education should not only expose students to knowledge but also ensure they experience the process of understanding and become able to formulate critical claims about the world.

It seems that for some students, the transformation from passive consumer to active producer had occurred later than they, in retrospect, had wished; some recognized it as occurring only in their MA studies. This echoes previous criticisms (Bowe et al., 2020; Parks et al., 2011) that research-related teaching may occur quite narrowly and late in communication education. Finnish CJ students engage in two theses processes in their studies, which enables them to engage in project-based research learning. However, we align with Ripatti-Torniainen and Kivimäki (2024) who argue that even intensive investments in research at the end of degree studies are not enough to engage students in research if there is a social prioritizing of practice over research throughout early stages of studies.

Our findings highlight the importance of generating and cultivating thinking through interaction with others, which is particularly meaningful for CJ students. The results of this study illustrate how thinking is not merely something happening within the individual but also occurring in communication itself. For example, group discussions emerge as important sites for developing and expanding one's thinking. Understanding the relativity and contextuality of knowledge is key to the scientific thinking needed by university students (Murtonen & Salmento, 2019). This kind of flexibility and multifacetedness is exactly what thinking together with others in communication may foster. Interestingly, our data also showed how unexpected crises might be experienced as impacting the collaborative development of thinking, as some of the interviewees discussed how the pandemic had taken away important communicative moments for thinking.

Pedagogical implications

A key conclusion for pedagogical development from this study is that it is crucial to make sure that students are exposed to research-related teaching and meaningful experiences, as well as intellectual challenges, early on. The process of scientific thinking skill development takes time. We encourage educators to make sure that opportunities for critical events are offered early on in education, to ensure a process of epistemic maturation. The need for sufficient space and time for development of thinking and knowledge has been emphasized before (e.g., Barnett, 2009; Harland & Wald, 2018). What should be critically discussed by educators is how to make sure that CJ students are engaged with suitable intellectual and theoretical challenges from the beginning of their studies. The beginning of university studies is a fruitful point of time for exposing students to scientific thinking and a research orientation emphasizing both what is known, and equally importantly, how we know what we know (Hofer, 2004).

Based on our findings, we recommend that university teaching staff as well as educational programs and faculties deliberately pay attention to the development of scientific thinking across the curriculum. Evaluating one's thinking skills may be hard for students (Virtanen & Tynjälä, 2018) —this was the case for some of our interviewees. Critical events could also be used as a pedagogical tool (see Lindh & Thorgren, 2016) to explicitly help students identify, evaluate, and reflect on the development of their thinking. For example, at the end of a course, students can be encouraged to, individually or collaboratively, identify events and moments in which their epistemic beliefs, understanding of research or knowledge etc. were challenged or changed in some way—and how. Reflection on how and in what ways one's thinking has changed should not be limited to research-related teaching, such as methods courses or seminars, but also encouraged in all disciplinary teaching. Such reflection could also be done in discussion with peers to encourage thinking together.

In a similar vein, it is important to formulate learning outcomes related to scientific thinking throughout theoretical and practical courses. In everyday teaching, we suggest explicitly emphasizing to CJ students that, for example, critical thinking, applying theoretical knowledge to practical challenges, as well as a general understanding of research and its relative and contextual nature, are all important professional skills needed to survive in the "post-truth" society, in which criticality is essential (e.g., Zou et al., 2023). Our findings illustrate that the development of scientific thinking is connected to students' ideas about themselves as emerging communication and journalism professionals. As students' progress through their studies, critical events that occur across theoretical courses and practical projects offer them opportunities for developing and applying their thinking skills in various contexts. Students should be encouraged to reflect on how their scientific thinking skills can be applied to identifying and solving problems, as well as developing solutions. These skills also develop in many ways in and through communication—preparing CJ students to work in the field of communication and journalism with individuals from various backgrounds and perspectives.

Limitations and future research directions

The findings of this study do not cover the whole scope of experiences related to the development of scientific thinking. Some of our interviewees had difficulty identifying any critical events or experiences. Our findings also focus mainly on the positive critical events the students perceived as strengthening their thinking skills. This is likely because of our interview protocol, in which we used the word "develop" that has a positively charged connotation related to change. However, we allowed the students to describe whichever events they thought of when thinking back to their studies. Studies employing the critical incident technique (e.g., Peltola et al., 2018) have often specifically asked the participants to identify both positive and negative events. Such an examination could also offer insights into the potential pedagogical pitfalls regarding the development of scientific thinking.

We examined the students' accounts of critical events that had occurred over a relatively long period: up to five years. The maturation of thinking skills, such as epistemological understanding (Virtanen & Tynjälä, 2018; 2019) and critical thinking (e.g., Bowe et al., 2020), takes time, and a longer period between experiences and data collection may have enabled the students to reflect on their learning and thinking processes in depth. However, an immediate data-gathering procedure, for example right after a course has ended, could enable a more detailed account of changes in thinking processes. Our study provides workable insights that can be used to develop curricula. The wide scope of this examination might, however, be reflected in some of our findings. We did not give the students a narrow definition of critical events, which might be why longer processes, such as the BA thesis process, stand out in the accounts. A more fine-grained analysis could provide detailed information for developing specific course outlines, supervisory practices, or further analyzing the intersections between expertise and scientific thinking in communication education.

Future research could focus on the field-specific features of scientific thinking within the communication sciences disciplines. Although our aim was not to compare the two fields of journalism and communication, some tentative field-specific differences can be observed, especially as they relate to the emergence of the students' professional identities over time and across critical events. For the journalism students, the experienced capability for critical reflection on knowledge and the field of journalism seemed to stand out as key for developing a journalist identity. The communication students consistently highlighted the communicative aspects of scientific thinking, such as being exposed to multifaceted views, and mirroring one's thinking with that of others. Their expression of professional identity is in many ways built on interaction. These possible differences, their origins in education, as well as their implications for both teaching and working life, could be examined more thoroughly.

Currently, communication and journalism students and professionals face the challenge of not only learning to critically and ethically use AI but also communicating its possibilities and risks to various audiences and stakeholders (Bowen, 2024). Another pressing question to be tackled in future research related to scientific thinking is the transformation of thinking from an individual and interpersonal activity to thinking in collaboration with AI.

Research on scientific thinking within CJ education remains largely underexamined. With this study, we hope to offer insights for further research and pedagogical development. This study focused on the characteristics and experienced outcomes of critical events from the perspective of students. Our analysis has thus broadened the understanding of key experiences related to the development of scientific thinking and how this process can be further supported in communication education.

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OTSIKKO JA ASIASANAT SUOMEKSI:

Kriittiset tapahtumat viestintäalojen yliopisto-opiskelijoiden tieteellisen ajattelun kehityksessä

ASIASANAT: journalismi, kriittiset tapahtumat, laadullinen tutkimus, tieteellinen ajattelu, viestintä, yliopisto-opetus