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ORIGINAL PAPER

Developing Disciplinary Literacy in an EMI Lecture: Real-time Monitoring of Student Comprehension Challenges in Philosophy of Science

在全英語授課課堂中發展學科素養：科學哲學課堂學生理解挑戰之即時監測

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Abstract
Despite an abundance of research on English medium instruction (EMI) in general, few studies have concentrated on how EMI is used to teach humanities subjects. Even fewer studies have monitored the development of, and hinderances to, disciplinary literacy in a moment-to-moment fashion in EMI lectures. To address this gap, the present study investigated student comprehension challenges in an EMI philosophy of science lecture, a discipline that values argumentation and dialogue in knowledge construction. The lecturer was interviewed about her perspectives on teaching philosophy in EMI, where she emphasized the language-heavy nature of the subject. Three students used a novel footpedal device to indicate points in the lecture that they struggled to understand. The device provided "time stamps" that were used to locate the challenging episodes in the lecture video recording. Students then joined stimulated recall interviews where they described the causes of their comprehension difficulties, and thus, impediments to disciplinary learning. Findings showed students experiencing top-down challenges related to the subject-specific content the most, followed by bottom-up, environmental, multimodal, and affective aspects. Pedagogic strategies based on the findings are then provided.

摘要
儘管有關全英語授課（EMI）的研究已相當豐碩，然而少有研究聚焦於如何運用 EMI 教授人文學科。更鮮少有研究能以動態即時的方式，監測EMI 課堂中學科素養的發展及其阻礙。為彌補此一研究缺口，本研究探討一門 EMI 科學哲學課堂中學生所遭遇的理解挑戰；科學哲學為一門在知識建構歷程中看重論證與對話的學科。首先訪談授課教師，了解其對以 EMI 教授哲學的看法，該名教師特別強調該學科具高度語言負荷之特性。隨後，三名學生使用一款新穎

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的腳踏板裝置，即時標記課堂中其難以理解的段落。該裝置產出的「時間戳記」被用於標記課堂錄影中具挑戰性的教學片段。接著，學生進行刺激回憶訪談，描述其理解困難的成因，進而揭示其學科學習阻礙。研究結果顯示，學生最常遭遇與學科特定內容相關的挑戰是由上而下的層面，其次為由下而上、環境、多模態及情意層面的挑戰。本研究最後提出相應的教學策略。

Keywords English medium instruction (EMI) · Lecture comprehension · Listening · Disciplinary literacy · Philosophy education

關鍵詞 全英語授課 • 課堂理解 • 聽力 • 學科素養 • 哲學教育

Introduction

Despite a rapidly expanding body of literature on EMI around the world (e.g., Bolton et al., 2024), research in particular subject areas remains underrepresented (Macaro, 2024). Furthermore, micro-stages of disciplinary development have not been readily accessible, with previous research relying on monolithic, static measurements such as quizzes, tests, and surveys. To be able to approach students' development of disciplinary literacy in EMI more closely, this paper applies a real-time monitoring approach using a novel footpedal device to capture moments of non-comprehension during an EMI philosophy lecture.

Every discipline carries with it certain traditions and discursive norms that are essential for learning about and establishing credibility within it. These disciplinary-specific norms form the basis for developing students' disciplinary literacies, broadly defined as "the use of reading, reasoning, investigating, speaking, and writing required to learn and form complex knowledge appropriate to a particular discipline" (McConachie & Petrosky, 2009, p. 6). Teachers' responsibilities include exposing students to those subject-specific norms and expectations and evaluating the extent of students' abilities to act appropriately within those academic discourses.

Because of disciplinary differences in the role that language plays in knowledge construction, the use of English presents various challenges across EMI contexts (Kuteeva & Airey, 2014). The ontology and epistemology of a given discipline will have a strong impact on how language is used for teaching and learning (e.g., through teacher speech, class discussions, PowerPoint slides, assigned readings, examinations). As such, a main pedagogic goal of teachers should be increasing students' disciplinary literacies relative to the subject.

As Airey (2025) observes, EMI is employed to teach a range of subjects, spanning disciplinary differences, as evidenced in courses and course literature from the hard sciences to the humanities. Kuteeva and Airey (2014) note that the most common EMI subjects have traditionally been hard sciences and hard applied subjects like engineering, where content knowledge and canon are generally agreed upon, well-established, and largely immune to criticism. In such subjects, knowledge exists regardless of the language used to express it. Hultgren (2024) points out that business and STEM subjects are most frequently offered in English, with humanities courses most often

taught in the local language. In "softer" subjects, the very language used to convey ideas can impact the ideas themselves, or at least the perceptions of those ideas (e.g., Kuteeva & Negretti, 2016). However, some humanities disciplines clearly stand out when it comes to the use of English to teach academic content. One such discipline is analytic philosophy with its strong Anglophone basis, in which knowledge making and language use are closely intertwined (e.g., Contesi & Terrone, 2018). As part of this scholarly tradition, philosophy of science – the focal discipline in our study – is particularly interesting, as it often combines the discursive norms of analytic philosophy with science-related content and terminology.

Teaching disciplinary literacy, which includes subject-specific semantic, grammatical, structural, and discourse norms (e.g., Airey, 2011; Richards & Pun, 2022), can be a daunting task, which becomes further complicated by varying second language (L2) proficiency levels, amounts of subject-specific background knowledge, general academic acumen, and motivation. Meanwhile, many EMI teachers value their role as content teachers but, per several previous studies, express scant recognition for the role that language plays in their teaching and in the learning of their students (e.g., Airey, 2012; Block & Moncada-Comas, 2022). To investigate the ongoing development of disciplinary literacy within the EMI lecture setting, this study aims to address a gap in the literature, namely to monitor at micro-levels the construction of disciplinary literacy in an EMI lecture given in a humanities subject. It does so in the subject of philosophy of science, a humanities discipline seldom included in EMI studies on classroom learning. We address the following three research questions (RQs):

RQ1: What are the EMI lecturer's views on their use of English to teach disciplinary content?
RQ2: What comprehension challenges do the three focal EMI students report in one EMI philosophy lecture?
RQ3: Do individual EMI students report different comprehension challenges in one EMI philosophy lecture?

The first RQ explores the lecturer's previous experience in and views on teaching their subject through EMI. It aims to address gaps in previous reseach by acknowledging the role that teacher background variables and perspectives play in how EMI is delivered (Siegel, 2026). The second RQ is descriptive, aiming to catalog comprehension issues that arise in the lecture in focus. The third RQ investigates differences between individual student experiences of the same lecture. This combination of RQs provides perspectives from both sides of the teacher-student relationship, which is seldom incorporated in situated EMI research.

The paper begins by providing a disciplinary perspective on the subject of philosophy before zooming out on disciplinary knowledge in EMI and the EMI lecture context in particular. After establishing this background, it moves to describe the idiodynamic methodology for data collection and analysis, which involved students using a novel footpedal to record time-stamped instances of comprehension challenges during the lecture and then discussing these instances in post-lecture stimulated recall interviews. An interview with the lecturer, analyzed through qualitative content analysis,

complimented the footpedal readings and recorded lecture in order to integrate content teacher perspectives in the research. Findings are reported through a systematic analysis of reported moments of non-comprehension, including top-down, bottom-up, affective, multimodal, and environmental issues, which is followed by a discussion of the results from a disciplinary knowledge construction perspective in EMI.

Background

Disciplinary Knowledge and Disciplinary Literacies

Various distinctions are made between different disciplines in higher education, with arguably the most common being divides between natural sciences, social sciences and the humanities (e.g., Bernstein, 1999; Biglan, 1973; Dang, 2018). Airey (2025) points out that disciplines in the natural sciences represent the largest area in which EMI is used, at least in the context where our study was conducted, with a much smaller proportion of humanities subjects being taught in L2 English, with the local language typically being used more in the teaching of undergraduate (bachelor) courses and programmes. The disciplinary differences between different fields are evident when viewed as hierarchical or horizontal knowledge structures (Bernstein, 1999). The hierarchical nature of the natural sciences is established by the notion that "new knowledge must always be compatible with pre-existing knowledge" (Airey, 2025, p. 51). In contrast, the humanities feature horizontal knowledge structures where systems of description do not need to agree with and/or build on one another but can exist simultaneously.

Philosophy is defined as one of the humanities by scholars (e.g., Richards & Pun, 2022), national education authorities (e.g., Malmström & Pecorari, 2022), and international educational, scientific, and cultural organizations (e.g., UNESCO, n.d.). However, such definitions do not take into account fundamental distinctions between different traditions within the discipline, as Western philosophy has been split into two "apparently irreconcilable camps: the 'analytic' and the 'continental'" (Levy, 2003, p. 284). It is analytic philosophy that is taught and researched in the context where our study was conducted. In this tradition, the concepts of clarity and precision are central to discursive norms in the discipline. Analytic philosophers believe their task to be similar to scientific inquiry, forming hypotheses and then testing and disseminating findings for wider discussion amongst peers, thus valuing knowledge construction typical of both the sciences (e.g., testing hypotheses) and the humanities (developing argument in dialogue with others) (e.g., Kuteeva, 2023). To this day, analytic philosophy has not received attention from EMI scholars, a gap the present study begins to address.

Each discipline has "a core set of assumptions, concepts, ideas, and theories, together with the processes and modes of thinking and inquiry" (Richards & Pun, 2022, p. 129) that defines it and sets it apart from other disciplines, although subjects can overlap in certain ways, leading to interdisciplinarity. In philosophy of science – our focal discipline – the analytic philosophy approach is applied to explore scientific concepts and theories, thus requiring a broad knowledge basis for the development of disciplinary literacy. Developing disciplinary knowledge involves contributing to the established communicative practices and demonstrating the ability to accomplish academic tasks in a particular

field (e.g., Airey, 2025; Richards & Pun, 2022). Students need the requisite literacy skills (i.e., both receptive and productive) to contribute to those discourses. They need to have sufficient vocabulary within the discipline and be aware of semantic, syntactic, structural, and pragmatic expectations for engaging with the disciplinary community. To help students in accessing such disciplinary resources, teachers often make pedagogical decisions as they mediate between established content knowledge and students' ongoing learning.

Frameworks for Understanding Disciplinary Knowledge in EMI

Airey's (2011) "Disciplinary Literacy Triangle" situates the society, academy, and workplace at each point of the triangle. Depending on the main goals of a discipline, it might be located closer to or farther from these points. Airey (2025) exemplifies this structure by observing that nursing has goals closer to the society/workplace edge of the triangle, whereas history as a discipline would be more appropriately placed near the academy/society edge. In attempting to operationalize the concept of disciplinary literacy, Airey (2011, 2025) provides a "Disciplinary Literacy Discussion Matrix" that includes the three designations from the triangle with prompts covering language skills (both local and English) as well as other modes of information communication (e.g., visuals, mathematical formulas). In the case of philosophy of science, the subject examined in this paper, we would argue that it, like history (another of the humanities), is less practical and more abstract, without direct links to practical application in terms of workplace (i.e., few, if any, people would state their occupation as "philosopher"). It is therefore situated near the academy/society edge of the triangle. Analytic philosophy is a language-heavy, Anglophone subject and therefore language skills in English are of high importance, given the conceptual nature of the subject and the thought-exercises that are involved.

There is currently no single definition of disciplinary literacies for EMI, but Dafouz et al. (2025) detail three types of language practices representing their different aspects:

1. Language practices to access the (EMI) disciplinary community;
2. Language practices to develop knowledge structures;
3. Language practices to display expertise.

As our study focuses on an EMI lecture, the first two aspects are particularly relevant. The first aspect concerns how students gain familiarity with the linguistic or multimodal expression of thought patterns within a specific discipline/disciplinary cluster. In undergraduate EMI in particular, the discourse community is envisaged as quite broad (e.g., a natural/social/human science or even academia in general) as students are just beginning to grasp how language is used in these areas. The second element concerns the development of knowledge structures and is more closely linked to specific disciplines. All modes and semiotic resources make part of disciplinary knowledge construction, but the main research focus has been on spoken academic genres (e.g., lectures, seminars, student group work), which reflects the importance of interaction and dialogue in knowledge construction. This second aspect is particularly relevant to our study as we zoom in on students' comprehension as part of their disciplinary literacy development.

EMI Lecture Comprehension Challenges

In the context of developing disciplinary knowledge and language, learning from lectures involves managing and integrating multiple streams of input (e.g., interpreting the teacher's speech, body language, board work, presentation slides, handouts, etc.) while performing various student behaviors (e.g., taking notes, using a laptop or phone to search for information, flipping through textbooks, fidgeting, etc.). As such, there is a multimodal element to lectures and a multitasking function on the part of students. Learning from lectures is a highly complex undertaking but one that is often taken for granted, with the assumption that simply attending a lecture is enough to effectively stimulate comprehension and learning.

Previous research has shown that EMI students encounter a number of challenges during EMI lectures, which ultimately impede their development of disciplinary literacy. These include inability to: parse the speech stream into individual words and chunks, recognize words in the speech stream that they know, in print form, identify key words and ideas, and effectively multitask (e.g., take notes while simultaneously listen as the teacher continues talking) (e.g., Airey, 2011; Ducker, 2022; Goh, 2000; Siegel et al., 2025a, 2026). Specialist vocabulary unique to respective disciplines (Dang, 2018) has also been reported as problematic (e.g., Zhou & Rose, 2024).

Many of the aforementioned studies illustrate the top-down and bottom-up listening challenges that EMI students encounter. The former group relates to schematic and background knowledge and the subsequent predictions that those knowledge-bases generate during listening. The latter refers to the actual processing of the acoustic signal once it reaches the ear (e.g., phoneme perception and parsing the speech stream) (Anderson, 2015). For example, Ducker's (2022) study of EMI students in a graduation thesis course in Japan found evidence of both categories, along with multimodal, interactive, lexical, and numeracy difficulties, when they watched videos of their classmates' presentations in English. Although Ducker (2022) utilized an idiodynamic methodology, participants in that study evaluated video recordings of the events via computer after they had occurred, rather than providing ratings in real time. In Ducker (2024), which introduced the footpedal system and the broader data collection procedures adopted in the current investigation, the instructor examined his own class. In other words, he was the teacher, giving him an emic perspective and degree of influence and power relations as the teacher-researcher. Consequently, the dual role of teacher and researcher may have shaped the manner of lecture delivery, potentially compromising the authenticity of the EMI lecture context. Furthermore, because the instructor subsequently conducted stimulated recall interviews with students, their responses may have been influenced by hierarchical dynamics and/or the Halo Effect (Nisbett & Wilson, 1977). The present study addressed these limitations by (1) gathering data in situ during the lecture itself; (2) engaging a teacher and students with no prior affiliation with the research team; (3) incorporating teacher insights into the study; and (4) positioning the researchers in an etic capacity (e.g., as observers of the lecture and when interviewing students).

Methods

The study reported here is part of a larger research project which adopts a real-time monitoring approach to examine EMI lecture comprehension, building on the idiodynamic approach (e.g., Ducker, 2024). This approach to data collection and analysis is inspired by Complex Dynamic Systems Theory (CDST) (de Bot, et al., 2007; Larsen-Freeman & Cameron, 2008), which highlights individual, changeable measurements when participants are exposed to the same stimuli (in this case, the lecture). For the present research, the approach is operationalized through a novel footpedal device that allows participants to report, in real time *during* the lecture (i.e., not while watching a video-recording), any instances of non-comprehension registered as time stamps. This data collection method allows participants to register non-comprehension in real-time, thereby avoiding the time delay of previously-used methods (e.g., post-listening quizzes or surveys). In addition, the real-time data collection serves to highlight the dynamic, individualized nature of lecture comprehension and the degrees to which students adapt to the situation, elements linked to a CDST perspective. The output generated during the EMI lecture reveals patterns and tendencies in terms of individuals' cognitive processing problems and strategies (Goh, 2023) as well as learning experiences when exposed to "the same classroom phenomena," interpretations of which accentuate individual differences under "the same conditions and contextual stimuli" (MacIntyre & Ducker, 2022, p. 2).

Research Context

This study was conducted at a public urban university in Sweden, where the faculty and student body are largely multilingual and multicultural. This diversity is facilitated by European Union initatives for mobility, including Europe's Civic University Alliance (CIVIS) and the European Community Action Scheme for the Mobility of University Students (ERASMUS) programmes. English has a strong position in Swedish society in general (e.g., Hult, 2017) and in higher education, where a recent report indicates that English is gaining in all academic domains in relation to Swedish, the national language (Malmström & Pecorari, 2022). At a more general level, Sweden ranks #8 among 123 countries in an annual English proficiency index, indicating the high levels of presumed English ability in the country (English First, 2025).

Data Collection Procedures

Prior to the lecture, the lecturer sat for an interview with one author to collect information on the lecturer's background and viewpoints on teaching in English (35 min). This interview provided relevant insight into the lecturer's perceptions of disciplinary literacy and her experience of EMI, which were essential to address RQ1 (see Appendix 1 for the lecturer interview protocol). Student participants joined an introductory interview session, which included a background survey,

discussion questions about academic experiences, and scaffolded footpedal training using short videos of lectures (60 min per participant) (see Appendix 2 for the background survey and initial interview questions). The footpedal mechanism consists of four plastic footpedals that are connected to a small data processor. When participants push the footpedal, a raspberry-pi chip marks those pedal presses at the corresponding second, thereby providing second-by-second data (i.e., a time stamp). In other words, the pedal allows the listener to immediately indicate any moments of non-comprehension. While the time stamps provide information about *when* during lectures the participants experienced comprehension challenges, it does not provide reasons *why* the pedal was pushed; therefore, post-lecture stimulated recall interviews were used to elucidate those reasons. Following the initial interview and footpedal training session, participants, along with non-participating students, attended the lecture, which was video recorded. During the lecture, participants used the footpedal device.

Immediately after the lecture finished, students took a 10-question true/false quiz, which helped to validate footpedal readings. Students were allowed to use their notes on the quiz. Within 48 h of the lecture, students joined individual stimulated recall interviews (90 min per study participant), where footpedal data and video playback of moments in the lecture when the respective student had pushed the footpedal were discussed with each student individually to gain insight into their reasons for non-comprehension (see Appendix 3 for general post-lecture interview questions). To elicit reasons for non-comprehension, researchers probed the time-stamped moments by asking, *Why did you push the pedal at this point?* and *What were you thinking here?*

The EMI Lecture and Study Participants

A university lecturer in philosophy (Shelli, a pseudonym) and three students (Axel, Bruno, and Celia, all pseudonyms) attending one specific "target" lecture participated. All participants provided informed consent. The lecturer had four years of EMI experience in Sweden after completing her undergraduate studies in her L1 in a European non-Anglophone context and her doctoral studies in English in the US, where she had also designed and taught analytic philosophy courses to L1 English undergraduates. An open recruitment invitation was made to all students in the class, and three participants were selected from those who expressed interest due to linguistic background and availablility for all parts of the data collection. The footpedal device, with a maximum capacity of four participants, was able to accommodate the three focal students, who had ranging L1 backgrounds and academic experiences, as detailed in Table 1, with their CEFR levels in English being approximately B2-C1.

As illustrated in Table 1, Axel had taken previous university courses in philosophy that were taught in English. Bruno and Celia had both taken high school level philosophy classes that were taught in their L1s (German and French, respectively). One of Axel's previous university courses in philosophy was on scientific realism and was taught in English. When elaborating on responses to his background survey, he pointed out that "[scientific realism] is philosophy of science, but it's a very

specific area." He also mentioned that he frequently listens to physics podcasts in English, giving him access to background knowledge in that field as well, the lack of which affected Bruno and Celia during the lecture (see the "outside the target discipline" code introduced below). Bruno had studied on an aesthetically-oriented German Abitur program in high school and Celia on a health science program. Axel had taken a natural sciences program in high school, which may have added to his relatively strong foundation for understanding the lecture in question. While Axel had ample EMI experience in the target discipline prior to the lecture, Bruno, and Celia in particular, had much less.

The Lecture

The lecture in question was part of Philosophy of Science 1, which considers important questions within philosophy of science since the beginning of the twentieth century and covers key topics such as scientific explanation, scientific theories, and how scientific conclusions are reached. It lasted approximately two and a half hours, including two short breaks, with the lecturing time totaling 143 min, and was attended by approximately 30 students in total, including the three study participants. Regarding lecture content, topics like the realism-antirealism debate, Hume's riddle of induction, the principle of the uniformity of nature, the raven paradox, and hypothetico-deductivism were covered, illustrating the highly-disciplinary specific nature of philosophy of science and the language needed to teach/learn it.

Lecturer Interview Analysis

To answer RQ1, the study adopted a qualitative approach based on one semi-structured interview. Qualitative inquiry seeks to produce detailed, context-sensitive, and descriptive data from a limited number of participants (Creswell, 2013). In line with Dafouz et al. (2016) and Choi and Poudel (2024), the data were analyzed using qualitative content analysis. This methodological orientation recognizes the existence of multiple realities, supports naturalistic inquiry, and foregrounds participants' perspectives and lived experiences (Selvi, 2019). As an initial analytic scaffold, the interview questions (see Appendix 1) were used to delineate broad thematic domains, following the procedure outlined in Choi and Poudel (2024). Drawing on a dynamic view of teacher identity (Siegel, 2026; Yan et al., 2023), the interview guide addressed the lecturer's linguistic and educational background, as well as her perspectives on several areas, including her self-concept as an EMI instructor, group characteristics, and students' L2 English proficiency. The interview protocol was piloted with one EMI instructor from a different humanities subject.

Real-time Data Analysis Procedures

The student participants' reasons for pushing the pedal, collected during the stimulated recall interviews, were categorized based on a multi-level coding system for lecture comprehension challenges (Siegel et al., 2025a) that includes top-down,

Table 1 Student participant details

	Axel	Bruno	Celia
Gender	male	male	female
L1	Swedish	German	Canadian French
Other languages	English, Spanish (beginner)	English, Latin (high intermediate)	English, Swedish (beginner)
Languages outside classom	Swedish	German	French and English
Grade for final English course prior to university	B (English 7; a high-level elective English course in Swedish high school)	A (German Abitur, high school Grade 12)	B (in the highest level English course offered in Canadian high school)
Experience of EMI	Social science and history in high school; other philosophy courses at university; programming at another university	Sporadic use of English at home and university; no EMI as such before Sweden	None before starting university studies in Sweden

bottom-up, affective, multimodal, and environmental factors. These five main categories incorporate more specific codes (e.g., the category "top-down" is divided into language-related, content-related, sociocultural, and individual cognitive processing issues) (see Siegel et al., 2025a, for a comprehensive explanation of the coding scheme). Due to the sometimes entangled nature of participants' explanations, dual coding was used (i.e., the same statement might be assigned two separate codes). Student responses were coded by the three members of the research team. Discrepancies or uncertainties in coding were resolved through discussion among the team. Table 2 includes selected examples of the coding scheme. These codes were selected because they were among the most prominent from this data set within their respective categories. The comprehensive coding scheme, including defintions and examples, is available in Siegel et al. (2025a).

During the coding process, it was noticed that Siegel et al.'s (2025a) coding scheme was not sufficient for all data; therefore, two additional codes were created (namely, "outside the target discipline" and "reflecting/processing time needed"). "Outside the target discipline" was used when content from subjects other than analytic philosophy – above all related to natural sciences – is used and is mentioned by participants as being beyond their "expectations for knowledge needed in the course in question", therefore causing confusion. "Reflecting/processing time needed" covers instances when participants say they were thinking about and/or trying to recall previously learned content while processing present input.

Results

This section starts by briefly presenting the EMI lecturer's perspective on her lecturing experience in Sweden (RQ1), followed by a comparative analysis of students' reported challenges during the target lecture (RQs 2 and 3).

The Content Lecturer's Perspective on the Role of Language

Regarding the role of language in the course, Shelli was quick to point out that "it's not part of the course goals for them to learn English, right? It's about philosophy." In doing so, she emphasizes the content-oriented nature of lecture, where comprehension of the language seems to be a given, and her statement aligns with the majority of previous research on content teacher views on language in EMI (e.g., Airey, 2012; Block & Moncada-Comas, 2022); that is, that disciplinary content rather than language is their main focus. At the same time, Shelli pointed out the importance of language in the discipline by stating:

> philosophy is an extremely language-heavy discipline. Being precise in your vocabulary, your language use is part of what doing philosophy is like. And it also happens to be the case that especially analytic philosophy of science, which is what I've taught most, is an Anglophone discipline (...) Like it's almost all done in English, written and spoken.

Table 2 Examples of coding scheme with stimulated recall interview excerpts

Category	Code	Definition	Statement
Top-down> >Language related	Lexical knowledge issue	Limited to single words/phrases of the everyday/ common academic variety; new/unknown word or known word but used in unfamiliar way/ context (e.g., metaphors, polysemy)	It was about "inferences." And I didn't know that word. (Bruno)
Top-down> >Content-related	Lack of prior (disciplinary) knowledge	Concepts, meanings, specific to the discipline	I remember I read through the slide and I saw this term, like conversationalist strategies or something. Yeah, I wasn't sure about what that meant and I also felt like I should have heard this term before. (Axel)
Top-down> >Content-related	Explanations	More abstract explanations/definitions	It may have to do with good and bad arguments, in which way she meant good and bad arguments. Because also it's kind of like the natural thing that this can mean several things depending on the context. (Bruno)
Top-down> >Individual cognitive processing	Notetaking/Writing time needed	Focusing on writing notes rather than on aural/ visual input	I might have been writing something in my notes and kind of got distracted. (Axel)
Bottom-up	Accent/prosody/intonation issue	Specifically mentioned as inhibiting comprehension	I have a harder time following people that have a very nasal voice and my classmate there had a very nasal voice. And because of that, it reduces more my attention span. (Bruno)
Bottom-up	Rate of speech issue	Overload in aural processing; pace of speech in general	I think it's just like [understanding] the whole process is the problem, probably, because she's talking fast. (Celia)
Affective	Emotional reaction to input	Content and/or delivery of spoken input was understood but emotionally unsettling	So it was something that she said that was plainly wrong in that sense and that did not attribute to understanding the concept better. (Bruno)
Environmental	Input from another student	Student (not lecturer) input interrupts comprehension	[Another student] said a certain term, but I couldn't hear it really well. (Celia)

As such, Shelli is keenly aware of the importance of semantic meaning and argumentation in her discipline, making it distinct from other subjects. She also noted she has struggled to express key philosophic terms and ideas in languages other than English, mentioning discomfort when talking about her subject with family and friends in her L1 (a Germanic language) and with colleagues in one of her additional languages, Swedish: "there's certain terms in philosophy that just don't quite translate." Thus, the "Anglophone" profile of the subject is highlighted.

Shelli feels she makes no adjustments in terms of course content when teaching in Sweden as compared to teaching such courses in the US to L1 English users, summarizing her main operating principle: "I just sort of teach in English and try to keep it accessible enough for everyone." Her overall assessment of her EMI students' language skills in Sweden is "very, very good" and she does not need to make her course easier than in the US, although she notes that sometimes they may "struggle to formulate a question." While seemingly indifferent of the language of instruction by using expressions of "just sort of teaching in English," Shelli mentioned the careful word choices she makes, and some confused reactions she receives if she uses "flowery language" that might not be familiar to some students in the class. She also commented that her rate of speech has been cited on course evaluations as being faster than students might be accustomed to. However, in the particular lecture under investigation in this study, speed was only a minor issue, with student participants mentioning rate of speech, speed of slides, and overload only a few times. During the interview, Shelli reported the strategy of writing on the board while lecturing, which she feels helps her control her rate of speech since she then only speaks as fast as she can write. This strategy of using the board was noted at several points during the lecture itself, and it seems to have been effective for helping her to maintain a rate of speech that was generally comprehensible for participants.

One important observation from the lecturer interview in relation to the student comprehension data was Shelli's understanding of the various sub-groups of students in her class. When discussing her students, she pointed out that while they did not tend to vary to a great extent in terms of their L2 English proficiency, their disciplinary knowledge, both in terms of general scientific background and in terms of previous exposure to philosophy, was noticeable: "my class is always a mix of students," including local and international exchange students. The differences in disciplinary backgrounds and amount of prior university education clearly manifested themselves among the three student participants in this study. For example, as shown in the section below, two students reported confusion because the lecturer, at multiple times throughout the lecture, spoke about scientific concepts outside of the domain of analytic philosophy.

To summarize, Shelli positions her course as content-driven, emphasizing that its primary aim is the teaching of philosophy rather than English, while acknowledging that philosophy—particularly analytic philosophy of science—is inherently language-intensive and deeply rooted in Anglophone academic discourse. Although she reports making no substantive adjustments to course

content when teaching in Sweden compared to the US, she remains attentive to lexical precision, speech rate, and clarity, using strategies such as writing on the board to regulate pacing and support student comprehension. She also demonstrates awareness of variation in students' disciplinary and linguistic backgrounds, points that factor in to the analysis of students' reported comprehension issues described below.

Overall Comprehension Issues Reported

During the stimulated recall interviews, 73 instances of non-comprehension were discussed, which resulted in 93 coded instances (where some instances were double coded). Axel had the fewest, with only 9 separate instances, followed by Bruno with 39 coded instances (after three self-reported non-relevant pushes were removed from the data set), and Celia had the most, with 45 instances. Only 12 of the overall instances (13%) fell in the multimodal or environmental categories, meaning these comprehension issues were considered to be external to the listener. The remaining 81 instances (87%) were categorized as top-down, bottom-up, or affective comprehension challenges, indicating that they were internal to the listener. Students also reported a mistaken or non-relevant push three times, and these instances were subsequently removed from the data set.

As displayed in Fig. 1, top-down issues were reported noticeably more than the other main categories (65 pushes/70%). Given the number of sub-categories within the top-down category (e.g., language-related, content-related, sociocultural, and individual cognitive processing) plus the specific codes within those sub-categories, this finding may not be surprising. Ten instances were of the bottom-up variety, relating to student processing of the aural input. The third most common category was environmental, with factors within the classroom, external to students themselves, affecting comprehension. Five instances were multimodal, in this case all related to the PowerPoint slides in some way. Affective reasons were reported the least, with 4 instances.

Top-down Factors

Separating the most-frequently reported set of challenges, the top-down variety, into the sub-categories (see Fig. 2), illustrates that the majority of pushes were of the content-related variety (44). The second most frequent reason for comprehension difficulty was individual cognitive processing, which totaled 14 instances. A large discrepancy between content-related issues and the comparatively low number of language-related issues (7) suggests that these students were able to understand the language used in teaching but struggled at times to make sense of some of the points in relation to the disciplinary meaning. This finding supports Shelli's observation that the majority of students have sufficient L2 English proficiency to understand the course content.

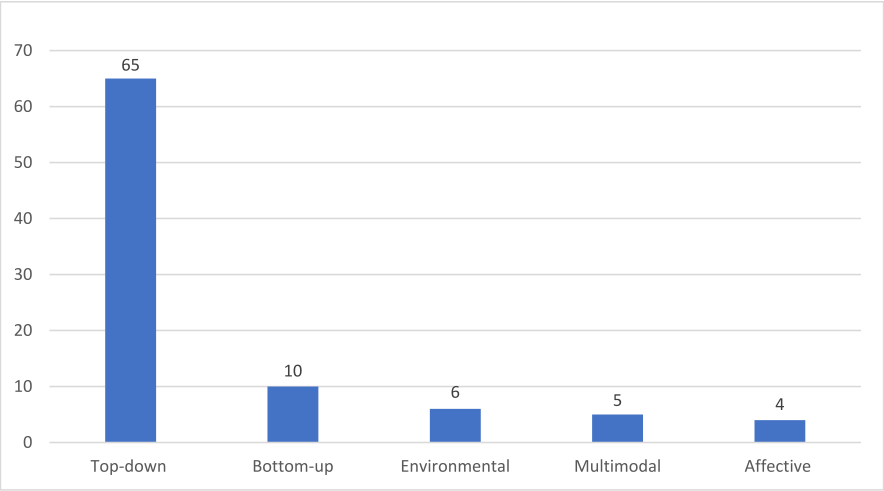

Fig. 1 All reported reasons for non-comprehension

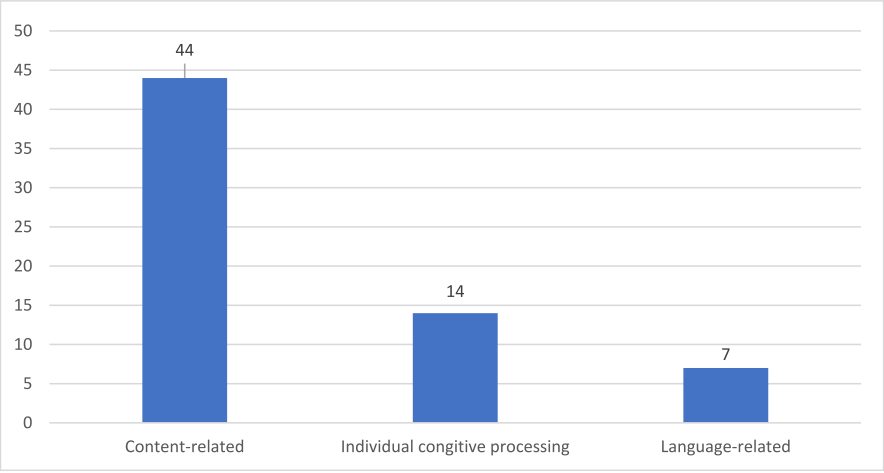

Fig. 2 Top-down reasons for non-comprehension

A more detailed examination of the content-related reasons shows some variation in the frequency with which the issues arose (see Fig. 3 below).

This level of analysis reveals that the code "uncertainty about/lack of prior knowledge" was reported most frequently (17) followed by the code "trouble understanding more abstract explanations/definitions/concepts" (14). "Uncertainty about/lack of prior knowledge" was expressed by all three participants, with the following excerpts serving as illustrative examples:

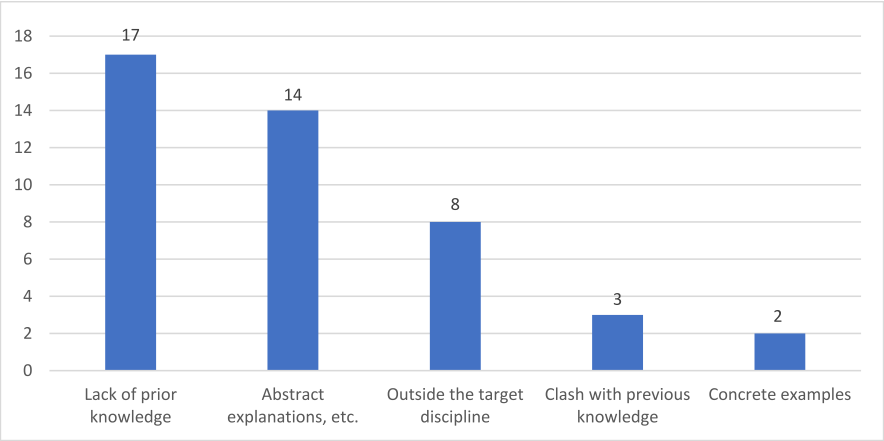

Fig. 3 Content-related reasons for non-comprehension

> Axel: "Yeah, I remember I read through the slide and I saw this term for this, like conversationalist strategies or something. Yeah, I wasn't sure about what that meant and I also felt like I should have heard this term before."
> Bruno: "Yeah, it was about the no miracles argument. I left the last lecture early [and therefore did not know what the lecturer was referring to]."

Related to abstract explanations/definitions/concepts, the following exemplify participant perspectives:

> Bruno: "in regards of selective realism, that in that moment I didn't grasp how you can be selective about what part you choose to apply your theory and what not, because that seems rather random to me and subjective."
> Celia: "Yeah, it's the example is not...well, it's not an example, but how she explains it, I'm not sure I was following all the way...the way the argument is constructed [confused me]."

Other content-related issues were clashes with previous knowledge (3) and understanding concrete examples (2).

> Axel: "That sounds like a very weird characterization of physics because that doesn't like, jam with my understanding of what physicists do day to day" (clash with previous knowledge).
> Celia: "I think it's just like the whole example, it goes pretty quick with the... like it's not developed too much…it's just like she's explaining the way the falsification works, and then she adds the whole example in between, so it's just like how she jumps from one thing to another" (understanding concrete examples).

The complex nature of the lecture content—the philosophy of science being introduced in connection to the field of physics—can be observed through these quotes. Examples are typically provided to illustrate and to solidify understanding

of abstract concepts. However, in this case, comprehension is hindered due to the lack of pre-existing knowledge of physics and its disciplinary bound terms.

The intersection between analytic philosophy and science in the case of our target lecture resulted in an additional code for the top-down content-related issues: "outside the target discipline." The data were coded as such eight times, all occurring when the lecturer attempted to illustrate points using knowledge from natural sciences. Examples include the lecturer's references to specific concepts and terms, e.g., "typhoid," "enumerative," "neutrinos," "detector metal," "optic fiber cable," as well as theoretical frameworks, such as quantum mechanics, and the differences between Eucledian geometry and relativity theory. These references caused confusion for Bruno and particularly for Celia, who was in her first semester of university studies. Although Bruno had studied philosophy before, he registered three moments of non-comprehension ranging from an unfamiliar theory to specific terms:

> Bruno: "Because I firstly don't grasp it fully, the concept of quantum mechanics."
> "I put my foot on the pedal because she said typhoid."
> "It's about a word enumerative. Or how you pronounce it. I've never heard it before."

Likewise, Celia was struggling to understand the difference between Eucledian geometry and relativity theory, because she did not have enough background in the latter.

> Celia: "Yeah, [I pushed the pedal here] because [the lecturer] goes back into some specific physics, so like the Euclidean geometry, all of that."

Although the lecturer briefly defined "neutrinos" as elementary particles, Celia found it hard to follow the argument because she had not heard this word before. Some other terms and concepts used to illustrate philosophical debates also impeded Celia's comprehension:

> "it's about the detector metal. (…) It's just like the fact of the detective metals and all of that. I'm not sure. (...) Yeah, I think it's just detector. That's a word that I don't see the relevance or the link with everything else."
> "I don't know if it was physics or something, but there's some cable things. Yeah, I think it's just some specific terms that I don't know about.

Bottom-up Factors

Issues related to perceiving and parsing auditory stimuli were reported 10 times, making it the second-leading category of challenge reported in this study. All but one of these came from Celia, who mentioned a range of bottom-up issues; specifically, trouble with phoneme perception (3), parsing (2), accent/prosody/intonation (2), and rate of speech (2). An example of a phoneme perception problem is when Celia misheard the phrase "brain in a vat" as "brain in a bat". A parsing problem was also expressed in the following interview excerpt from Celia: "It's after [the word] 'remember', [the lecturer] says, 'but remember' and I guess it's 'theory,' but it might be like, yeah, how the words are pronounced is a bit kind of mumbling." Since Celia is not able to repeat the words the lecturer spoke after "but remember," she is seemingly unable to segment the speech stream into known words. Other examples are available in Table 2.

Environmental Factors

Environmental factors caused two types of non-comprehension: general non-verbal distractions (1) and input from another student (5) (see Table 2 for an example). Regarding the general non-verbal distraction, Axel explained: "someone just came into the classroom late, so I got a bit distracted by that. And I think I… when [the lecturer] began speaking again, I looked up at the PowerPoint slides and I couldn't quite remember what this had to do with [what the lecturer was talking about]."

Multimodal Factors

In the coding scheme, multimodality involves the lecturer's spoken output and other streams of communication such as PowerPoint slides and/or body language. Results from this study showed some challenges were caused by the slides themselves while others involved the combination of lecturer speech and slides. The most common reason in this category was misaligned input streams (5), which often involved the written text on a slide competing for attention with the lecturer's voice, as described by Bruno: "the slide just before that. And it was again like me reading further and then being caught up in the reading and not fully comprehending what she speaks."

One instance each of the codes "speed of slides" and "content/image on slide" were also evident. As for the former, Celia mentioned the lecturer had flipped through slides too quickly for her to process the information contained: "because it's just at the moment the slides change, so it might be that everything is a bit like [confusing]." As for the latter, Celia found a citation on one slide irrelevant, as "it's just that she doesn't develop on anything because […] she uses the citation." Speculating, it seems Celia does not infer any implied message the lecturer intends to communicate by displaying this citation. Such academic or discipline specific practices are often not explicitly taught, creating moments of confusion to newcomers to the field.

Affective Factors

Per the coding scheme, affective factors include the following codes: fatigue/listening endurance; boredom/lack of interest; stress-related/anxiety; mind wondering; and emotional reaction. Of these, only emotional reaction was expressed by Bruno throughout the lecture (see Table 2). None of the codes with presumably negative connotations related to lack of student motivation, interest, and attention were mentioned, indicating that a) the students were motivated, attentive, and interested in the lecture content throughout, b) the lecturer succeeded in delivering an engaging session that students wanted to pay attention to, or c) a combination of both.

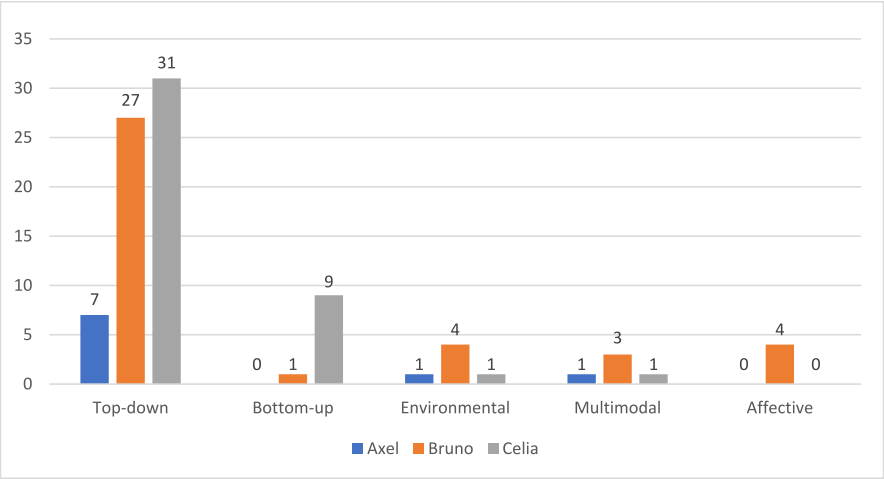

Fig. 4 Comparison of the 3 participants' reported comprehension challenges

Individual Differences in Lecture Processing

Regarding RQ3, which prompts a comparative view among the three participants, Fig. 4 demonstrates how the reasons for student pedal pushes differ. This type of individual comparison serves to highlight the dynamic, individualized nature of the lecture experience. It provides tangible data that illustrates how a CDST perspective plays out during real time lectures. Despite being exposed to the same stimuli (i.e., the lecture), the three focal students had diverse experiences.

Bruno is the only participant whose reasons fall into all five categories within the coding scheme. Celia (4 categories) and Axel (3) faced comprehension challenges in a narrower range. The top-down category was most common for all participants, and it is important to keep in mind that this category also contains the largest number of individual codes. All three participants experienced issues related to top-down, environmental, and multimodal influences, whereas only Bruno reported affective reasons for disrupted comprehension.

Despite this variation in reported non-comprehension, post-lecture quiz scores from the three participants are both high and uniform, with two scoring 90% and one a perfect 100%. This observation suggests that even though there were "bumps in the road" throughout the lecture, these may have been isolated and did not detract from the overall learning of the content the lecturer wished to deliver. Another possible explanation for the quiz scores is that students may have learned that information earlier and/or elsewhere (e.g., from course readings, class discussion) than the lecture itself.

Discussion

This study adopted a real-time monitoring approach on comprehension challenges in one EMI philosophy of science lecture, addressing a "language heavy" humanities discipline whose object of study extends its remit to the natural sciences. To begin with, the content lecturer was interviewed to collect her thoughts on analytic philosophy as a discipline that is taught via EMI. During the target lecture, students reported moments of non-comprehension via a footpedal that produced "time-stamps" of those moments, which were called up on the lecture video during stimulated recall interviews. Students then explained their reasons for reporting an issue in understanding.

The initial RQ concerned the lecturer's perspective on the role of language in philosophy of science and how language may affect students' lecture comprehension. The lecturer strongly emphasized the Anglophone nature of the discipline and the need for strong English skills in learning and discussing it. The need for language precision was evident in the lecture, likely representative of the wider discipline, as it included several thought-experiments and exercises and very few, if any, overtly practical applications. This observation confirms that the subject falls near the academy/society edge of Airey's (2011) "Disciplinary Literacy Triangle." Moreover, Shelli highlighted that the majority of students she works with have high L2 English proficiency, and despite several moments of reported non-comprehensions, her view is supported by the 90—100% post-lecture quiz scores. Shelli also showed clear understanding of her students, remarking on the various types of knowledge that can fluctuate within the student group, which demonstrates a holistic "language-related knowledge base for content teachers" (Seah et al., 2022); in other words, Shelli is acutely aware of the role language plays in her discipline.

The second and most expansive research question focused on the overall comprehension challenges the three student participants faced. These challenges were categorized per Siegel et al.'s (2025a) coding scheme. The vast majority of the reported issues fell within the top-down category and the content-related sub-category, indicating that students had few problems with the language of instruction per se and instead encountered more specific struggles while developing their disciplinary knowledge in philosophy of science. Some challenges with bottom-up processing of teacher speech, multimodality, and environmental aspects were evident, but to lesser degrees. These findings are largely in line with the small amount of previous research from another discipline in the Swedish university context (Siegel et al., 2026), where students typically have strong L2 English proficiency. Research conducted in other disciplines but using a similar method in non-European contexts (e.g., Ducker, 2022, 2024) showed a higher propensity for reporting bottom-up language problems. These problems are similar to what was reported decades ago by Goh's (2000) ground-breaking research on the listening comprehension problems of Chinese students. Viewed more broadly, these findings also correspond to the complex, dynamic nature of the EMI lecture experience.

The final RQ centered on individual differences among the three student-participants in relation to their reported comprehension challenges. As evidenced in Fig. 4 above, the main commonality was that all students reported top-down issues more than any other category. Clear differences were also evident, not only in the total number of reported instances but also in the nature of the non-comprehension

issues themselves. Axel reported far fewer issues in comparison to Bruno and Celia. Regarding student backgrounds (see Table 1), Axel had the most prior academic experiences with the discipline, and those experiences were in English. This may have better prepared him to follow the present lecture content than Bruno and Celia. They had taken some more basic philosophy classes in their L1s in high school, but reported far more comprehension challenges than Axel. When lecture content that seemed to be outside of the immediate target discipline came up, Axel's physics podcast habit proved beneficial. He did not press the pedal at those moments, while the other two participants failed to understand examples from the hard sciences.

Meanwhile, Bruno's reported issues in all five categories, further suggesting the expansive range of influences that come into play during the lecture experience, both internal and external to the listener. In contrast, Celia reported frequent issues with discipline specific terms and practices, as well as natural science content knowledge, suggesting the breadth of cross-disciplinary knowledge required of the students in this particular lecture. The students' varied previous general academic, language-related, and disciplinary experiences are likely to have impacted their individualized experiences in this single lecture, findings that can be associated with their diverse linguacultural and educational backgrounds (Table 1). In Ducker (2022, 2024), this may have been the case as well; however, in those studies, little background information on the individual participants is given.

In the present dataset, the presence of difficulties spanning three to five broad categories indicates that lecture comprehension is shaped by multiple, interacting factors for each student—an observation that aligns with a CDST perspective and one consistent with the limited existing research. In Ducker (2022), participants reported experiencing between three and seven of the eight identified problem categories as sources of comprehension breakdown at different points while viewing videos of classmates' presentations. Similarly, in Ducker (2024), the four participants described a range of difficulties, including bottom-up, top-down, lexical, and knowledge-based issues during a lecture taught by the researcher himself. One difference between the present study and Ducker's (2022, 2024) previous work is L2 English proficiency. Ducker's participants had lower proficiency (e.g., the 2022 study included students with CEFR levels from A2-B2 and the 2024 study specifically selected students "reporting the lowest TOEIC scores" (p. 192)). In contrast, the three participants in the present study were estimated to be at CEFR B2-C1 level. Despite the variation in proficiency level, the range in and combinations of comprehension-related issues that can arise during lectures likely complicates instructors' efforts to implement pedagogical adjustments that effectively address all students' needs.

When L2 English proficiency is high (e.g., at minimum B2 level on the CEFR), as in the case of our student participants, it seems logical to expect our findings to be trasnferable to other humanities subjects, based on this limited investigation in philosophy. In other language-heavy disciplines, the students who choose to enroll in such programs are likely aware of the need for strong proficiency in the language of instruction, with the expectation that their disciplinary literacy will develop via that language (English, in many cases). Therefore, this study supports the notion expressed by others (e.g., Airey, 2025; Tsui & Macaro, 2025) that in EMI humanities subjects among high proficiency students and teachers, content-based rather than language-related challenges are the ones that typically arise during learning. This would seem to be the case in "mature" EMI contexts that have established systems for, and expectations

of, EMI (e.g., Block & Moncada-Comas, 2022; Siegel et al., 2025b). Context, and thereby general L2 English proficiency, arguably impacts the types of non-comprehension that may be evident in EMI research. In this study, both the lecturer and the three students participants have demonstrated their ability to participate in language practices required for developing different aspects of disciplinary literacy, particularly with regard to developing knowledge structures (Dafouz et al., 2025). On the other hand, relatively newer EMI contexts such as Kazakhstan and Taiwan have reported issues related to EMI teachers' L2 proficiency levels (e.g., Manan & Hajar, 2024; Siegel et al., 2025b), while research on EMI student comprehension set in Japan has reported roughly equivalent levels of top-down and bottom-up processing issues in EMI teaching (Ducker, 2022), suggesting that comprehension is hindered at the level of decoding the speech stream before it can progress to more meaning building levels.

Pedagogic Implications

Shelli, the teacher in this investigation, seems to have been largely successful in helping the students develop relevant aspects of their disciplinary literacy during the lecture. Study participants' post-lecture quiz scores were high, and in the post-lecture interviews, they stated that they understood between 75% (reported by Celia) and 95% (Axel) of the lecture. These subjective estimates also align with footpedal use. Based on our interpretation of the data and the lecture experience, the teacher gave a clear and engaging session, and the student participants were motivated and successful in learning. That said, several pedagogic implications can be gleaned from this study, which are likely relevant not only to philosophy lectures but to broader, language-heavy humanities subjects as well.

To limit comprehension difficulties, general strategies such as paraphrasing important points, using student-friendly examples, and expressing the same idea in different ways (e.g., through speech, images, and interaction) can be effective. The most evident cause of non-comprehension here was lack of prior disciplinary knowledge. This observation suggests teachers might pre-teach or highlight key terms and concepts for students prior to actively applying them. Assigning pre-lecture readings and/or written activities that introduce such items can be helpful in allowing students to process them at their own pace (i.e., through reading, reflection, etc.). This can make recognition of those terms and concepts easier in the live lecture setting, where the speed of information can come very quickly and is largely beyond students' control. Another strategy for addressing prior disciplinary background knowledge is to present short tasks and/or other needs analyses at the beginning of a course. That way, the teacher can be aware of content knowledge and language proficiency levels among the student group, something that Shelli, in her interview, noted. Since following abstract explanations was also identified as a frequent challenge for participants during this lecture, use of advanced organizers (e.g., partially-completed tables, mind maps, etc.) could help students follow explanations, better understand abstract concepts, visualize connections between concepts and concrete examples, and notice the ways in which certain concepts differ from others. When an explanation might be vague or theoretical, the tangibility of an advanced organizer can be an asset. Structured peer-to-peer interaction on abstract concepts can also help; for example, using prompts such as "try to restate this argument in

your own words" or "what premise does this claim rely on?". Encouraging students to (re)articulate theoretical concepts can improve learning and can be especially valuable in language-driven humanities subjects like philosophy.

This data set also showed some students being confused by information from other disciplines. When teachers wish to bring in such content, they might consider ensuring they provide sufficient background knowledge that some students may need in order to understand such examples and/or providing additional more generally-accessible examples as well. It can also be important for EMI teachers to be clear and explicit about the relation between new knowledge they are introducing for the first time and information that has already been established on the course (e.g., through readings, previous lectures or courses, presumed shared knowledge, etc.), as students may miss such linkages. When using slides, teachers should be conscious of aligning their spoken output with the images and/or text displayed on the slide. It seems prudent for teachers to comment on the relevance of anything included in the slides. One practical strategy to avoid student confusion via misaligned input streams can be for the teacher to "blank" the screen if they suddenly decide to talk about something that is not included in the current slide content. Doing so would likely signal to the student that the slide is not relevant at this time, but the teacher's speech is.

Shelli was able to control her rate of speech by periodically using the whiteboard to write out some key points, a valuable tactic for teachers who may talk too fast at times. Still, the pace of the lecture proved challenging for these three students at some points, evidenced by their individual cognitive processing issues, in particular time to write notes and reflect on/recall previously learned content. Therefore, other strategies to both manage the pace of the class and to allow students some time to digest content include: intentional pauses for student notetaking and/or reflection, adding brief pair work so students can consolidate information (e.g., "check if your neighbor understands this point," "ask your neighbor if they remember this point from our last class," or "take a minute and compare your notes with the person sitting next to you"). Such strategies allow students to cooperate and potentially resolve comprehension issues amongst themselves while also creating interactive opportunities for learning. EMI teachers can try out these types of teaching techniques on their own or as part of systematic EMI teacher support programs, such as those outlined by Deroey (2023) and Morell et al., (2020).

Limitations

The findings reported in this paper focused on a single lecture in one humanities subject (philosophy of science) and the related experiences of that lecture as reported by three students. The investigation arguably allowed for a detailed analysis of the moments of non-comprehension reported. Part of a larger study, the findings reported here are not meant to be generalizable but, ideally, transferrable to similar contexts. The analysis also offers comparative opportunities with other studies and begins exploration in lesser-researched EMI subjects. Caveats also relate to the footpedal itself, with students potentially using the tool inaccurately, although the initial training session was meant to help offset this weakness. In addition, students may not be well-versed in articulating their comprehension difficulties, which can lead to ambiguity and reliance, at times,

on researcher interpretation. Following the coding scheme (Siegel et al., 2025a) and discussion and cross-checking of coding amongst the research group is meant to strengthen the robustness of the findings. Finally, stimulated recall interviews can be problematic because of memory issues and time between the lecture and the interview itself. To help offset these concerns, interviews were held within 48 h of the lecture.

Conclusion

This study provided insights into the disciplinary literacy development of three EMI students in one EMI philosophy of science lecture by examining comprehension challenges they experienced. The combination of teacher and student data presented both sides of teaching–learning in EMI that is rarely represented in other research, which typically focuses on one side or the other. The paper offered strategies for EMI education that are likely to be useful in humanities subjects in particular and may transfer to natural and social sciences as well. As the present research took place in a single context and with highly-proficient English users, similar investigations in other contexts and within other disciplines would expand our understanding of the relationship between language, pedagogy, and learning. This study also focused on a single lecture, whereas a longitudinal perspective would allow for tracking if and how comprehension challenges evolve over time and how students attempt to overcome them through learning strategies. Future research could further examine whether certain reasons for non-comprehension are more prevalent among specific student groups, in certain disciplines, and/or in relation to EMI teachers with different backgrounds. All such work would underscore the importance of a CDST perspective on learning that accentuates individual student experiences.

Appendix 1: EMI lecturer interview protocol

What is your first language?

What language(s) do you use when teaching (e.g., English, Swedish, other)?

What subject(s) do you teach?

How do you view yourself as a teacher who uses English?

How did you learn the subject?

How long have you been teaching this subject?

How long have you been teaching in the current format? (e.g., in English, Swedish, other)?

Do you see the students having sufficient English proficiency to complete the course?

Do you think the students' English proficiency affects their comprehension of the lecture?

Do you adjust the class delivery to take into account students' linguistic proficiency? If so, how?

Are there any teaching strategies or language you use to help students understand better?

Could you comment on your use of visual aids in teaching?

What factors go into your design and use of such visual aids?

Is there anything else you think might be relevant?

Appendix 2: Student participant pre-lecture interview and background survey

Student Background Survey Questions

Name of course: _____

Day of class when footpedal will be used: _____

Assigned letter: _____

Student name: _____

Gender: female / male / non-binary / other (please specify)_____

Mother tongue(s): _____

Other language(s): _____

Language(s) used most often outside the classroom: _____

Program of Upper Secondary School (Gymnasium): _____

Did you study subjects in English during Upper Secondary School? Yes /No

If so, what? _____

Have you taken other university courses in English? Yes /No

If so, what? _____

Last English language course you completed in Swedish Upper Secondary School: (e.g.,

English 5, 6, 7). _____

Grade in the last English language course you completed in Swedish Upper Secondary

School: F, E, D, C, B, A _____

Student Pre-lecture Interview Questions

How much experience have you had studying different subjects in English? For example, a biology class taught in English, a math class taught in English, etc.

How would you describe your comfort level with listening in classes given in English?

How would you describe your comfort level with assigned readings written in English?

Appendix 3: Post-lecture interview protocol

How did you experience the lecture in question?

In the class/lecture/lesson that you just attended, roughly what percentage of the class do you think you understood?

Was this the first time you attended a teaching session given by this teacher?

How would you describe the teacher's teaching style?

Have you studied anything similar to this course content before? In your first language or in a second/additional language? If so, what, where, when?

Was there any preparation reading or assignments for this lecture? Did you do them? Why/why not?

Were there any strategies that you used to understand the lecture content?

In particular, are there any points that you have been having difficulty with in this particular class or lecture?

What was it like using the footpedal in the class or lecture?

[After these questions, the interview continued by focusing on the moments of non-comprehension indicated by the footpedal time-stamps].

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Data availability Data related to this paper will be made available at a Stockholm University figshare page prior to publication.

Declarations

Ethical approval Ethical procedures approved by the Swedish Ethical Review Board (2024—00061—01).

Consent to participate and consent to publish All participants signed written consent forms stating that they agree to participate in the study and that findings can be published.

Conflict of interest There is no conflict of interest.

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