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COGNITIVE CARTOGRAPHY: MAPPING STUDENT NOTE-TAKING ACROSS DISCIPLINES

We qualitatively examined student note-taking across engineering, medical, and social sciences to understand how artifacts reflect disciplinary epistemologies. Using completed notes (n = 17 students; 617 pages) and brief elicitation interviews, we analysed cognitive structuring, affective/aesthetic cues, and social affordances. Engineering notes were linear and monochrome, optimised for application and exams; medical notes relied on schematic icons and comparative tables for memorisation; social-science notes showed the widest variety, including humour, mind maps, and collaborative artefacts that supported reflection. We do not assess learning outcomes; rather, we interpret note-taking as information practices and extended cognition. Findings suggest that instruction should move beyond uniform, reproduction-based habits towards adaptive strategies that align with disciplinary demands whilst supporting metacognition and collaborative sense-making. We provide implications for teaching note-taking as a transferable, lifelong skill.

Key words: *note-taking, mind mapping, disciplinary epistemologies, information practices, extended cognition, higher education.*

Introduction and current state of the research problem. Alongside the growing popularity of chatbots that summarise literature (Chen et al., 2025), alternative forms of note-taking, such as mind mapping, concept mapping, and collaborative note-taking, have gained worldwide traction (Buzan, 2018; Barta et al., 2022; Asyah, Faradiba & Bahri, 2024). As a result, we are observing a growing number of studies on their effectiveness in learning, ranging from collaborative note-taking (Costley, Fanguy, 2021) to the application of mind mapping with children in early education (Kaczor, 2020) and on an academic level (Radomski, 2019).

Both the skills required for note-taking and the perceived importance of notes are gradually permeating Polish education, even though neither primary nor secondary schools provide systematic support for developing these skills (Gryboś, 2021). Despite some changes in teachers' attitude, the core curriculum offers little variety in acceptable note-taking approaches (cf. MEN, n.d.), and teachers still inspect these competencies even at the high-school level (Kowalikowa, 2012). Materials that go beyond traditional note-taking methods have appeared on the Integrated Educational Platform (ZPE, n.d.), a service of the Ministry of National Education dedicated to support teachers. However, due to the instructions accompanying these materials, students have limited freedom of action. As a result, note-taking ceases to fulfil its primary function – supporting the creation of individual associations and building personal connections with the content (Braszko et al., 2025). Drawing on diverse examples of student notes from Poland, we argue that mind mapping may be especially valuable in educational systems with stronger teacher–student hierarchies and higher deference to authority, where opportunities for critical-thinking can be constrained (Ho et al., 2023).

A year ago, we set out to examine our classmates' note-taking habits and needs (Braszko et al., 2025). It was intended as participatory action research, yet, we did not anticipate our peers being reluctant to share their notes, which resulted in a small sample size (4 out of 39). The limited scope of our initial study prompted us to investigate more broadly. This time, we sampled beyond our cohort and discipline, including courses distant from the social sciences that require learning approaches different than we used to. The small sample still restricted the generalizability of our findings, but the diversity of approaches to note-taking in the general population must be no smaller than within our poll of the gathered examples.

In the theoretical background, we draw on heutagogy to frame note-taking as self-determined sense-making. Heutagogy refers to self-determined learning in which learners assume responsibility for content, pace, and style of learning (Blaschke, 2012). In this view, note-taking becomes a tool for reflection and sense-making rather than mere transcription. Annie Murphy Paul (2021) explores how human thinking expands beyond the brain through external tools and social interactions. She examines the concept of "joint attention" – when multiple individuals focus collectively on the same object or idea – demonstrating how this shared focus amplifies information processing and meaning-making. Whilst Paul provides numerous examples of extended cognition in action, from gesture-enhanced learning to distributed problem-solving, she doesn't specifically investigate collaborative note-taking practices. This omission leaves room for inquiry into whether the cognitive benefits she describes might extend to shared note-taking scenarios. In the context of note-taking, Jamie Costley and Mik Fanguy (2021) expand this concept by examining how cooperative work affects cognitive processes. Their research demonstrates that shared note-taking can enhance comprehension yet risks added coordination load. Their study, however, lacks broader descriptions of the methods presented to students before implementation, which led to the overload.

Collaborative note-taking can be extended to include mind mapping. The collaborative mind mapping intervention demonstrated dual cognitive and social benefits: (1) it scaffolds deeper structural understanding of complex concepts through visual-spatial representation, whilst (2) functioning as boundary objects that minimize disciplinary tensions and aligns divergent perspectives through shared artifact creations (Zahedi & Heaton, 2016). This approach can increase students' critical thinking, despite different challenges across disciplines and various learning styles. According to Ho et al. (2023) collaborative learning promotes critical thinking, by encouraging learners to discuss different viewpoints, their strengths and weaknesses and construct new ideas. By creating a shared mind map, all students can explore a topic or problem and develop it further grounding on input of others, thus realising the idea of "multiple perspectives" (Buzan & Griffiths, 2011 as cited in Ho et al., 2023). Through working together, students can better "identify the relationships between different ideas, concepts, and pieces of information" (Paul & Elder, 2006 as cited in Ho et al., 2023) and, by finding relationships between concepts, students can "achieve metacognition" crucial to deeper understanding of the topic and improve later recall (Willingham, 2008). This method works not only for academic students but also for preschool children in developing social skills (Özgül et al., 2021).

Goal and objectives. We conducted a qualitative, exploratory study of students' note-taking practices in higher education, focusing on cross-disciplinary differences across engineering, medical sciences, humanities and social sciences. Rather than testing effects on memory or performance, we explored how students create and organize notes and how these information practices reflect broader epistemic orientations.

Accordingly, the goal of the study was to map cross-disciplinary note-taking practices, and the objectives were operationalised as the three research questions:

– how do students from different disciplines organise and present their notes?

– what visual and material affordances characterize students' note-taking artifacts?

– what implicit strategies, values, and emotional investments emerge through students' annotated materials?

Research methods. This framing informed our decision to analyse completed note-taking artefacts as situated, tool-mediated traces of students' engagement with disciplinary knowledge. Note-taking is a nearly ubiquitous practice in higher education, yet it remains undertheorised as a form of *information practice* (Zhong, Han, & Hansen, 2022). Drawing from this framework, our study views note-taking not only as an individual cognitive aid, but also as a socially situated, tool-mediated activity that reveals how students interact with disciplinary knowledge, construct meaning, and prepare for both exams and future professional tasks.

The study was based on the collection and analysis of completed student notes – primarily final versions, not drafts or notes taken in real time. These artefacts were supplemented by short, informal interviews and chat-based exchanges with the authors of the notes. Standard guiding

questions included: 'How did you come to this note-taking approach?' and 'How has it changed over time?'

This dialogical component allowed us to gain insights into personal trajectories of note-taking practices, including prior educational influences and evolving preferences.

As an ethical statement, we note that the study was conducted in accordance with the principles of research ethics and received approval from the Ethics Committee at the University of Gdańsk (No. 46/2024/WNS). Participants were informed about the purpose and nature of the study, as well as the anonymity of their data. We obtained their oral consent to participate, along with electronic confirmations. Written consent was waived for practical reasons whilst maintaining compliance with ethical requirements.

Regarding our analytical strategy, we combined visual-content inspection and theoretical coding. We did not assess knowledge accuracy or learning outcomes. Instead, we attended to how content was selected, organised, visualised, and annotated. Specifically, we examined:

– Cognitive structuring: graphical representation of information (e.g., diagrams, tables, colour coding) as indicators of extended cognition (Clark & Chalmers, 1998; Hyerle, 2009).

– Emotional and aesthetic features (e.g., humour, personalisation, stylisation) as signals of affective engagement.

– Social affordances: signs that notes were shared, reused, or designed with communicative value (e.g., summary tables, clarity of layout).

Our theoretical lens integrates Illeris' (2003) three dimensions of learning (cognitive, emotional, social) with affordance theory (Gibson, 1979; Ditzler et al., 2018), which shifts attention from what notes are to what they afford (e.g., highlighting, copying, teaching from, revisiting). Table 1 summarises the corpus we analysed (participants, page counts, mode of note production, and tools used), broken down by discipline.

Results. Amongst students of medical and health-related disciplines, a strong tendency to use symbols or pictures could be observed, often repeated in similar patterns. For example, a drawing of a face with a tissue, represented illness. These aesthetically neat graphics were primarily functional rather than expressive. The symbols lacked abstraction and often resembled textbook diagrams. The use of notes primarily served individual purposes, with memorisation being their main function. The figures are presented as illustrative exemplars of the observed note-taking styles rather than as representative averages of disciplinary practice. An anonymised example of this functional, exam-oriented note-taking style is shown in Fig. 1.

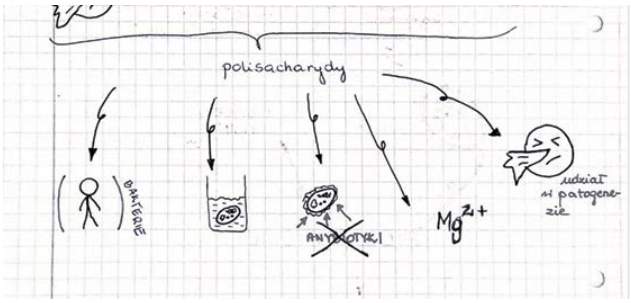

Fig. 1. An anonymised excerpt of a medical/health sciences note page (handwritten, paper-based, squared paper)

It shows a fragment of the notes of study participants who declared they were studying biology. The iconographic diagram of the development of polysaccharides is repeated on subsequent pages of the notes. The figure illustrates a functional, exam-oriented style in which arrows, simple pictorial symbols, and sparse verbal labels condense causal or associative relations for memorisation. Reproduced in grayscale for print compatibility.

However, they may also be useful to other students because of the universal nature of the notes, for example comparative charts. There were attempts to create personalised notes, but elements of reflection or the transformation of knowledge into new meaning were minimal. This suggests that the notes functioned more as condensed microlearning aids, focused on compressed and rapid microlearning, rather than as a foundation for personal knowledge, where connections between texts and individual associations are most important.

According to the students, effective memorisation depends primarily on highlighting key information using large text or capital letters, and drawing attention to content (Sweller, 2024) through the use of different colours (colour coding). Students expressed dissatisfaction with their previous, linear note-taking techniques, which proved ineffective at the university level because of the sheer volume of material that needed to be learned.

The broadest diversity within the field was observed in the notes of students in the social sciences. These were the only ones that included collective note-taking, along with a wide variety of forms and styles. Their notes widely employ symbols, small graphic, aesthetic features (seemingly unrelated text icons, drawings and frames), humorous elements (slang references, emoticons), and even personal reflections on complex topics, which indicated emotional and cognitive engagement. In addition to the traditional function of memorisation, reflective and interpretative

Table 1

Corpus overview by discipline (participants, pages, note-production mode, and tools used; n = participants; y = pages; values in the "Mode" and "Tools" columns are reported as participants/pages)

Discipline	Participants (n)	Pages (y)	Mode (n/y)	Tools (n/y)
Engineering	2	32	Individual (2/32); Collective (0/0)	Paper (0/0); Digital (2/32)
Medical sciences	4	160	Individual (4/155); Collective (4/5)	Paper (2/20); Digital (4/140)
Social sciences	11	425	Individual (6/308); Collective (5/117)	Paper (2/37); Digital (10/388)

purposes of notes were also noticeable here. At times, the notes resembled a way of organizing personal thoughts through mind maps or humorous descriptions. Figure 2 provides an anonymised example of such a mind-map-like note, where visual structuring coexists with expressive and humorous cues.

It shows a three-fold abbreviated version of the notes from the lecture "Pedagogical Diagnosis." It was created by the study authors as part of preparation for the exam. The figure illustrates a mind-map-like organisation in which conceptual clustering is combined with decorative framing, icons and humorous or expressive cues, showing that note-taking can support both memorisation and interpretation. Reproduced in grayscale for print compatibility.

Students pointed to key elements that supported memorisation, such as highlighting essential information with colorful headings, subheadings, and structuring content according to its level of complexity or difficulty. They also created drawings and graphics – ranging from simple icons serving as associative cues to more complex visual representations. Within the same field, more traditional, text-based forms of note-taking were also observed. These were well-organised and aesthetically, clearly structured, primarily aimed at memorisation, though sometimes supplemented with personal comments, especially on topics considered important for their future career. Even within these more mechanical approaches to learning, elements of reflection (like personal insights and questions) were still present.

Our analysis and interviews revealed that most social science students changed their note-taking methods during their studies, expressing dissatisfaction with the strategies they had used in school. Some students reported being accustomed to transcribing lessons word-for-word during their earlier education. Others mentioned that they did not take notes at all, as there had been no real need for learn-

Fig. 2. An anonymised excerpt of a social sciences note page (handwritten, paper-based)

ing outside the classroom. That corresponds with warnings about gifted children who later struggle because early schooling did not require them to develop learning-to-learn strategies (Kanapathy et al., 2022) However, some students experienced self-imposed pressure to create aesthetically pleasing notes, even though they wished to experiment with alternative approaches.

Engineering students (e.g., computer science, bio-engineering) tended to prefer a linear and monochromatic note-taking format. Their notes often consisted of uninterrupted sequences of sentences. No images or symbols were found in the collected materials, which may reflect the nature of their field of study with unambiguous and clear-cut structured information. The content of their notes is primarily focused on information that could be applied in project work, exams, or future professional practice. Even coloured headings are absent – colours were almost entirely nonexistent in any of the materials analysed. Students used either continuous text or column-based layouts when the volume of information made a linear structure impractical. The dominant purpose of note taking in this group was memorisation, with little to no signs of expressiveness or reflection on the subject matter. One student even used the basic Windows Notepad program to create notes, which seems to be the least flexible option.

Engineering students reported that their current note-taking style is similar to what they used in earlier stages of education. The form has remained consistent, with only the content adapting to academic requirements i.e. coding, memorising, comprehension, application. This stands in clear contrast to students in social science disciplines, who tend to adapt their notes in various ways, from details to the point of modifying the whole structure in response to the demands of higher education.

The collected data indicate that the function and style of note-taking depend on the field of study. Students in medical disciplines tend to produce simple, schematic, and functional notes – dominated by symbols, with little evidence of reflection. The primary purpose appears to be memorization. In technical disciplines, notes are strictly textual, lacking colour, graphics, or commentary. They serve as practical tools, created with exams or professional application in mind.

The greatest variety of forms and functions was observed in the notes of social science students. These included graphic elements, humour, personal comments, and attempts at interpretation. In this context, note-taking becomes not only a tool for memorisation but also a form of thinking and collaboration. Alongside creative and expressive examples, more traditional and structured formats were also present – though even these carried traces of individual engagement.

Despite these differences, a shared need for clarity, content organisation, and adaptation of note-taking methods to individual cognitive needs and learning goals was evident across all student groups, except for technical studies.

Discussion. Our study was based on the finalised notes only, which makes it difficult to reconstruct the temporal and processual aspects of note production. We also could not distinguish between prior and new knowledge that were both embedded in the notes. Consequently, higher-order thinking or critical reflection (Cañas et al., 2017; Kinchin et al., 2019) could not be directly assessed. The scarcity of Polish-language research on note-taking practices further limited our theoretical framework regarding cultural specificity, necessitating reliance primarily on international sources.

In the Polish context, students' accounts suggest that note-taking is still shaped by a school culture of reproduction and evaluation (e.g., notebook checking), which can limit early experimentation with form. This may partly explain why many participants reported changing their strategies only at university, where they begin to treat notes as an adaptive learning tool rather than a compliance artefact.

Although some differences between disciplines were observed, it remains unclear whether these variations can be directly attributed to the field of study itself, as other factors, such as the year of study, were not controlled for in this research. Nevertheless, given that students from different disciplines did not receive formal training in note-taking, the observed variation in both the structure and function of their notes – which reflects differing degrees of departure from conventional, protocol-based note-taking – can be plausibly explained by two complementary mechanisms. First, the specific nature of each discipline and the type of knowledge conveyed during lectures, appear to shape note-taking practices. Second, students may select disciplines that align with their preferred learning and note-taking styles, suggesting a reciprocal relationship between individual preferences and disciplinary demands. These patterns should be read with potential confounds in mind (year of study, instructor style, course mode). Besides, format alignment to discipline does not guarantee effectiveness – we did not evaluate knowledge accuracy or learning outcomes and our claims concern form, function and variety.

Disciplines that focus on practical or applied knowledge, such as medicine and engineering, typically favour note-taking styles that are structured, schematic, and functional. In contrast, disciplines that emphasize interpretation and meaning, such as the social sciences, tend to encourage more reflective and expressive approaches. These patterns illustrate that note-taking might not only be a cognitive skill but also a cultural practice, shaped by the norms and expectations inherent in each discipline.

From an educational perspective, these findings highlight the need to reconsider how students are taught to take notes at different stages of their education. Many students reported dissatisfaction with the traditional, reproduction-based note-taking habits acquired in primary school. Introducing more flexible and adaptive strategies could foster deeper understanding and critical reflection.

For teachers, a practical implication is to treat mind mapping not as a single technique to be adopted wholesale, but as a teachable repertoire that learners can appropriate and modify. The strongest gains may come from socialising note-taking: making notes visible as shareable study artefacts, organising brief "note galleries" where students

compare solutions to the same content, and occasionally producing a collective mind map that functions as a boundary object across different interpretations. This shifts notes from private compliance to public learning craft, while still respecting that effective formats remain personal and context-dependent.

Encouraging students to view notes not merely as a record of classroom teaching content but as a personal, evolving learning tool could help bridge rote memorisation and genuine comprehension. Importantly, developing the ability to adapt one's note-taking approach represents a broader life skill, reflecting the necessity to continuously learn and adjust to new knowledge and changing circumstances.

Conclusions. Previous research has shown that many students are dissatisfied with traditional note-taking methods taught in primary school. A particularly criticised aspect was the obligation to submit notebooks for checking and the lack of creative freedom. Here, in contrast, during their university studies, students appreciate the ability to tailor their notes to their individual needs. Our research confirms this shift: students employ a variety of strategies, including linear, graphic, and mind-mapping approaches, selecting them according to personal preferences and to learning requirements of their disciplines, to some extent. Customization is key. Aesthetics and structure can support memory retention, even when the artifact is idiosyncratic to its author. Technologies such as Notion or Onenote may facilitate organization and modification of content, though many students still prefer analog methods. The diversity of practices highlights a lack of sufficient education in modern note-taking techniques and tools.

Effective note-taking is strongly linked to individual approaches to organizing knowledge. Whilst school education favoured linear, aesthetically pleasing notes aligned with imposed standards, university students often experimented with various formats, ranging from abbreviations and colourful diagrams to drawings and humorous elements. The creative freedom not only improved their memory retention but also helped them develop personal learning strategies. The use of Tony Buzan's (2006) principles – such as colour, associations, rhythm and exaggeration – occurred intuitively rather than systematically. Even without knowing the theory, students appeared to apply some of its elements in practice, which they perceived as helpful. Adapting note-taking styles to one's needs and thinking patterns, proved to be an issue that needs further studies, especially in relation to academic disciplines and years of study.

Group work also emerges as a crucial factor for some students. Sharing materials, participating in joint revision sessions, and recording collaborative note-taking sessions enriched content comprehension and supported the development of deeper understanding.

The study further highlights the need to reconsider how note-taking is taught in formal education. Current methods – dominant since the early 2000s and still largely focused on uniformity, rigid structure, and visual neatness – fail to support the cognitive processes of many learners. The study adds to the argument that alternative techniques, such as mind maps, drawings, gestures or associative strategies, should be further introduced (cf. Ho et al. 2023). Instead of promoting a single "correct" way to take notes, schools in Poland should start providing space for exploration and reflection on students' own learning style.

The findings suggest that note-taking is a highly personal and context-dependent practice. Whilst school education often emphasizes uniformity, effective note-taking in higher education must align with individual learning needs and disciplinary requirements. Effective note-taking combines functional organization, personal expression and collaborative elements allowing students to both retain information and develop deeper understanding.

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КОГНІТИВНА КАРТОГРАФІЯ: СИСТЕМАТИЗАЦІЯ СПОСОБІВ КОНСПЕКТУВАННЯ СТУДЕНТІВ У РІЗНИХ ДИСЦИПЛІНАХ

Проведено якісний аналіз способів ведення студентами конспектів з інженерних, медичних та соціальних наук з метою з'ясування того, як такі артефакти відображають епістемології відповідних дисциплін. Використовуючи завершені нотатки (n = 17 студентів; 617 сторінок) та короткі інтерв'ю, проаналізовано когнітивну структуру, афективні/естетичні маркери, а також соціальні можливості взаємодії. Інженерні нотатки були лінійними та монохромними, оптимізованими для застосування та складання іспитів; медичні – ґрунтувалися на використанні схематичних піктограм і порівняльних таблиць для запам'ятовування; нотатки з соціальних наук характеризувалися найбільшою різноманітністю, зокрема гумористичними елементами, ментальними карти та спільно створеними артефактами, що сприяли рефлексії. Результати навчання не були предметом аналізу; натомість конспектування інтерпретується як інформаційні практики та прояв розширеного пізнання. Отримані результати свідчать, що навчання має вийти за межі одноманітних звичок, заснованих на відтворенні, у бік адаптивних стратегій, що відповідають вимогам конкретних дисциплін і водночас сприяють розвитку метакогніції та спільного осмислення знань. У роботі запропоновано рекомендації щодо викладання конспектування як універсальної навички, необхідної впродовж усього життя.

Ключові слова: *конспектування, ментальні карти, дисциплінарні епістемології, інформаційні практики, розширене пізнання, вища освіта.*

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