

Investigating Student Experiences with Curriculum Coherence

A Qualitative Study about the Computer Science Curriculum

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Abstract

This qualitative study explores how Bachelor's computer science students at TU Delft experience curriculum coherence across horizontal (concurrent) and vertical (sequential) dimensions. Based on semi-structured interviews analyzed using Reflexive Thematic Analysis, the results reveal how students view the trade-offs between academic depth and breadth, how well-timed repetition mitigates cognitive load, and how independence between parallel courses combats exhaustion. These insights highlight that curriculum designers should explicitly articulate connections between courses and carefully incorporate repetition to optimize student engagement.

1 Introduction

A well-designed education program should keep students engaged with the curriculum and assist their learning. One factor that influences their learning is the degree of coherence among the courses in the curriculum (Newmann et al., 2001).

In education and learning science, the definition of coherence may vary between contexts (Wang et al., 2024). For this study, coherence is understood along two dimensions: *horizontal coherence* focuses on how courses during the same time period of study relate to each other, whereas *vertical coherence* addresses how knowledge develops across sequential courses. (Thijs & van den Akker, 2009)

While prior research has analyzed the effectiveness of curriculum structures using quantitative metrics such as student performance data (Betancur et al., 2019; Lafleur et al., 2021), a research gap remains regarding the influence of these structures on how students learn. This study aims to bridge this gap by investigating students' perspectives on the coherence of their curriculum by conducting semi-structured interviews with final-year Bachelor of Computer Science and Engineering students at TU Delft. The data gathered aims to answer the following primary research question, supported by two sub-questions:

- "How do students experience the coherence of their curriculum?"
  - Horizontal coherence: "How do students experience taking multiple courses within the same educational level?"
  - Vertical coherence: "How do students experience the progression of knowledge between earlier and later courses in the program?"

By investigating these dimensions, this study contributes a vital empirical student perspective to the broader discourse on educational design. Specifically, it reveals how students view the trade-offs between academic depth and breadth, how well-timed repetition mitigates cognitive load, and how independence between parallel courses combats exhaustion. In doing so, this paper offers actionable insights for university faculty and curriculum designers seeking to optimize parallel and sequential course ordering in their program.

2 Literature Review

While prior research has examined the effects of the curriculum structure on student performance, the effect it has on the learning process itself has been examined much less. This section will briefly introduce related work: first, how they define coherence; second, how they address vertical coherence; and lastly, how they address horizontal coherence.

2.1 The Concept of Coherence

This paper will focus on *curricular coherence*, where the focus is on the structure of the curriculum, meaning "sensible connections and coordination between the topics that students study in each subject within a grade and as they advance through the grades" (Newmann et al., 2001, p. 298). This definition was also used by Schmidt et al. (2005), who focused on the progression of content in K-12 schools in the US compared to other countries.

Several other terms could also refer to coherence. These include but are not limited to instructional program coherence, instructional alignment, and integration (Wang et al., 2024). These further help guide the search for related works.

Inversely, many other papers have also covered coherence with a different definition in mind. The meaning of coherence can boil down to "things coming together", but what parts need to come together changes what it is in practice. Some examples of adjacent definitions in literature would be: how well taught content transfers to the real world (Fay et al., 2021), how well the teachers know what content to teach (Wang et al., 2024), and a culmination of multiple scales of coherence (Newmann et al., 2001). These works have mostly focused on what coherence means from the perspective of curriculum designers, showing its relevance across various contexts.

Other related work has also highlighted the importance of student perspectives in understanding curriculum design. Morales-Doyle (2018) shows that students actively interpret and evaluate their curriculum, with variation in how they perceive relevance and educational purpose. This shows that curriculum coherence is not only a structural property but also one shaped by student interpretation.

2.2 Vertical Coherence

This paper refers to the effectiveness of how courses build onto each other over time as vertical coherence (Thijs & van den Akker, 2009). To examine this concept, the literature on curriculum design is considered alongside similar topics such as instructional sequencing, course order, knowledge development over time, learning progressions, and curricular pathways or ladders.

One way to formalize the curricular structure is through prerequisite relationships between courses. The flow of knowledge can be represented as a *course-prerequisites network* (CPN) (Stavrinides & Zuev, 2023), where nodes represent courses and directed edges represent prerequisite dependencies. Such representations emphasize the structural constraints that shape possible learning trajectories and highlight how curriculum design can enforce or weaken sequential learning paths.

Courses that are well connected, such as spiral curricula where topics are revisited and deepened iteratively (Masters & Gibbs, 2007), are interpreted as having high vertical coherence. In contrast, the lack of connections is interpreted as having low vertical coherence. Additionally, excessive attempts at reinforcement to connect courses are also seen as low vertical coherence. This is known as the *expertise reversal effect*, where the effectiveness of this reinforcement decreases as prior knowledge increases (Kalyuga, 2007).

Vertical coherence has also been studied empirically through course sequencing interventions. For example, Betancur et al. (2019) investigate how variations in the ordering of methodological and topical courses within psychology affect student performance in later advanced courses. Their findings suggest that earlier exposure to foundational methodological content is associated with improved outcomes in subsequent coursework. Similarly,

Nguyen and Dao (2025) examine the sequencing of research methodology and research writing courses, combining grade data with student interviews to explore how course order influences both performance and student perceptions of learning progression.

2.3 Horizontal Coherence

Horizontal coherence refers to the alignment and relationships among courses taken concurrently at the same level of study. In contrast to vertical coherence, horizontal coherence focuses on whether parallel learning experiences reinforce each other, remain independent, or introduce inconsistencies in content, expectations, or skill development.

In the literature, horizontal coherence is commonly framed as alignment within a single educational level across subjects or domains. Thijs and van den Akker (2009) define horizontal coherence as the coherence between subjects and/or subject-transcending themes within the same educational level, emphasizing the coordination of content across parallel learning experiences. Similarly, Jin et al. (2019) conceptualize horizontal coherence as part of a broader system of curriculum, instruction, and assessment alignment, in which coherence refers to consistency across components of the educational system at a given point in time. Although these perspectives differ in scope, they both highlight the importance of coordination between simultaneously taught elements of a curriculum.

Empirical studies have examined the importance of horizontal coherence through different forms of concurrent course structures. Lafleur et al. (2021) investigate the effect of implementing a team-based learning course alongside traditional lecture-based instruction, analyzing workload and cognitive load during learning. Loder et al. (2025) studied students enrolled in multiple programs concurrently, examining the correlation between academic performance and aspects of student life to determine whether there is a noticeable change in workload.

3 Methodology

This section covers when and where the study took place, how participants were chosen, how the interviews were structured, and how code analysis was conducted.

3.1 Context

This study was conducted on the Bachelor's of Computer Science and Engineering at TU Delft in 2026. The program is three years long, with each year being divided into four quarters of three courses. The main exceptions to this are the software project and research project, which take the full quarter at the end of year 2 and 3, respectively, and the minor, which takes the first two quarters of year 3. The study itself took place near the end of the school year.

3.2 Participants

A total of six participants were recruited through purposive sampling: third-year students who had completed all courses in their curriculum except the research project. By no means should this be viewed as a representative sample of the student body; instead, the study should be considered an exploratory qualitative study aimed at generating insights into their experiences.

3.3 Interview Procedure

This study conducted qualitative research by using semi-structured interviews (Adams, 2015). Interviews are ideal for this study as they allow for in-depth perspectives from the participants. The semi-structured nature of it further supports this by allowing follow-up questions, while keeping the interview on topic to some extent.

The interview guide contains questions on vertical and horizontal coherence, respectively, seeking examples and follow-ups to delve further into how the participant experienced them. It contains questions regarding both the presence and absence of each type of coherence to investigate it fairly. The guide was pilot-tested prior to data collection to ensure the clarity and relevance of the questions. The questions are available in the interview guide attached in Appendix A.

All interviews were conducted in person and lasted approximately 30 minutes each. Participants were informed about the topic and purpose of the interview beforehand: when initially contacted and before the interview started. Informed consent was also obtained from all participants before the interviews. No financial or material incentives were offered for participation. Interviews were audio-recorded with participants' consent to ensure accurate capture of responses. These were automatically transcribed using Microsoft Dictation, an institutionally approved transcription tool. Transcripts were reviewed and cleaned to correct errors and ensure accuracy. All identifying information was removed during this process to maintain participant anonymity. Data was stored securely in accordance with institutional data management guidelines.

Data was analyzed using *Reflexive Thematic Analysis* (RTA) as outlined by Braun and Clarke (2022). This approach was selected for its flexibility for small, qualitative datasets focused on exploring participants' experiences. RTA does not seek coding reliability in a positivist sense; instead, it emphasizes the researcher's active role in interpreting the data.

Analysis followed six iterative phases: (1) familiarization with the data through repeated reading of transcripts; (2) systematic coding to identify meaningful features; (3) generation of initial categories by grouping related codes; (4) review and refinement of themes in relation to the dataset; (5) definition and naming of themes; and (6) production of the final report. Coding and category development were conducted iteratively, with ongoing reflection to ensure clarity and depth. Themes were developed inductively, grounded in the data rather than deduced from existing research. Some example codes and categories are embedded under their respective themes in Section 5.

4 Responsible Research

This section addresses responsible research practices in its interview process, reflexivity, and usage of artificial intelligence (AI). The process section outlines the ethical procedures regarding the interviews and data handling. The reflexivity section considers my position and interpretive role in the data analysis, consistent with RTA. The AI section explains how AI was used responsibly during the research and writing process. These demonstrate how ethical integrity and interpretive bias are maintained throughout the research.

4.1 Interview Process

This study is conducted in accordance with the requirements of the Human Research Ethics Committee (HREC). This process was carried out by my supervisor to ensure adherence to

professional standards of correctness. No interviews were conducted before written ethical clearance had been granted.

Participation is voluntary. Participants are provided with clear information about the study's purpose, procedures, and intended use of data prior to participation. Informed consent was obtained from all participants. Participants were informed that they could withdraw at any point. Participants may decline to answer any question or discontinue the interview at any time without consequence, and are reminded of this right when asked potentially sensitive questions, such as difficulties the participant may have had with the curriculum.

Confidentiality is maintained by anonymizing all identifiable data during transcription and reporting. Student names have been omitted in all outputs, and any contextual details that could reasonably identify participants or institutions have been removed or altered. Recordings and transcriptions are stored safely either locally or in SURFdrive, an HREC-approved cloud storage system.

Overall, the study is designed to respect participants' autonomy, protect personal data, and minimize harm while enabling systematic analysis of curriculum coherence.

4.2 Reflexivity

I conducted this study as a student with direct experience of the curriculum. This provided familiarity with its structure and student experiences, which supported the creation of informed follow-up questions during the interview and the interpretation of interview data. However, this shared background may have shaped assumptions about the correctness of responses. Additionally, this could allow participants to frame their responses much less formally. To address this, I remained attentive to how responses were formulated during the coding process, interpreting them based on what I believed the participant meant in the surrounding context.

Reflexivity was maintained through ongoing critical awareness of my position and its potential influence on data interpretation. I reflected on emerging codes and themes, considering their relevance to the research and how prior educational experiences may have shaped my interpretation.

4.3 Use of Artificial Intelligence

The use of AI tools was limited to supporting the literature search, text structure, and writing quality. Literature found using AI was carefully reviewed to assess its relevance and credibility. Structures generated by AI were rewritten to present relevant information more concisely. Grammar was corrected using AI. The analysis, interpretation, and overall argumentation were developed independently by me.

5 Results

This section presents the findings from the reflexive thematic analysis of the semi-structured interviews. The results are organized into three primary themes: the tension between knowledge depth and breadth in the build-up of knowledge, the impact of varying degrees of reinforcement, and the use of task-switching to manage motivation across parallel concurrent courses.

5.1 Vertical Coherence - Coherence Through Knowledge Depth or Breadth

The main observation regarding vertical coherence concerns the build-up of skills and knowledge in courses within the same learning path and between courses in different learning paths. The categories and initial codes for this theme are outlined in Table 1.

Table 1: Coding Structure for Theme 1: Knowledge Depth or Breadth

Category	**Example Codes**
Building up knowledge	direct prerequisite relationships, foundational skills persist
Disconnected content	perceived separation, self-contained courses
Broadening within a field	varied perspectives, field overview

Participants were able to identify individual relationships, for example: "ADS to AD, as you need the concepts you learn in ADS of complexity and so on to solve AD and to understand why doing brute force may not be the best idea." This and similar quotes are examples of how topics can effectively build on each other to understand more complicated content.

Foundational courses taken early result in skills and knowledge persisting throughout the curriculum. One participant said: "Every programming uses some parts of introduction to programming or object-oriented programming." This highlights the need to establish a foundation for the further development of knowledge across many courses going forward.

In contrast, a few participants struggled to identify repeated content. Despite the explicit learning paths, courses within the same path cover the same discipline, but different aspects within it. One participant stated: "I don't think this really builds up on each other because it is just very different compared to the past courses, because again, it's like databases, then you have AI, and now you have the human aspect of computing", indicating that content may appear disconnected, even within the same learning path.

However, they also state: "But I get why they would group them together, because AI, after all, is still data-related, but it's more like management versus using it." This indicates the broadening within a field, regardless of direct connections. A participant also claimed that "in bachelor's you want to get as like wide view of the field as possible," highlighting the necessity of this breadth in the bachelor's of computer science and engineering.

To summarize, students experience vertical coherence as a combination of knowledge depth and breadth. While clear prerequisite relationships and foundational courses support deeper understanding over time, these connections are not always explicitly perceived. When the curriculum emphasizes exploring different areas, courses may appear disconnected even though they belong to the same learning path. This suggests that vertical coherence is shaped by both depth through progression and breadth through variation, with students recognizing the value of both.

5.2 Vertical Coherence - Supporting New Content: Getting the Right Amount of Reinforcement

Vertical coherence was also discussed in terms of how knowledge and skills are retained, reinforced, or decayed over time. A recurring pattern in the data is that retention is closely

tied to the extent to which knowledge is repeated after initial exposure: whether it is placed appropriately, overly redundant, or missing entirely. This is reflected by the categories and codes in Table 2.

Table 2: Coding Structure for Theme 2: Getting the Right Amount of Reinforcement

Category	**Example Codes**
Well-timed repetition	refresher, cognitive load reduction, implicit reinforcement
Redundant repetition	wasted time, disengaging from content, loss of motivation
Structural gaps	missing knowledge, use of external support, vague understanding

A few participants reported repetition functioning as a reinforcement. For example, one participant stated: "For computer security, it makes more sense, I think, because computer networks is year one, so it's technically two years you might have forgotten it. So it makes sense to like at least touch on it." Here, repetition serves to refresh the students' memory to later build on it further. In such cases, prior familiarity reduced cognitive load, as reflected in statements such as: "I remembered having, like, being familiar with [it], oh yeah, you can do this." repetition was also explicitly valued as a supplement: "repetition is not necessarily bad... it can be very useful for people who had maybe glossed over it in the previous course."

When repeated content is brief, students noted that it did not interfere with their learning. When knowledge is well understood, repetition is glossed over rather than actively detrimental: "if you are able to be reminded of the topic that's repeated without needing much explanation, then your mind just doesn't really register that it was repeated." This indicates that reinforcement can function implicitly, supporting understanding without being explicitly recognized.

However, repetition was also described as redundant when it did not introduce additional depth or variation. In these cases, students perceived little added value and experienced a drop in engagement. For example, one participant stated: "In IDM, they just taught you SQL again... that felt really just not useful in that case," describing it as "wasted time." This redundancy was then associated with disengagement and reduced motivation: "if there [is] no new stuff, I'm not motivated to learn it."

Additionally, insufficient reinforcement led to knowledge gaps, which were experienced as disruptive. Missing or insufficiently developed foundations limited students' ability to engage with more advanced material. For example, one participant explained why they believe they struggled to understand a topic in one of their courses: " [It is] better if they go in depth [...] on how to use it instead of on the why and the tricks," and states that "it just assumed that you knew how to do it fully." This naturally led to a vague understanding of the new topic.

In response, students attempt to supplement the knowledge gaps. This included seeking external resources, such as using AI tools: "I would just try to get Gemini to explain it." In some cases, this additional effort contributed to a deeper understanding: "I remember that I asked Gemini this and then I had to look into the whole thing," suggesting that filling gaps can improve retention. However, reliance on external tools without conceptual understanding was also viewed critically: "ChatGPT gives you an answer, but... I don't really know what I'm doing," highlighting a distinction between procedural completion and conceptual learning.

Overall, revisiting content appropriately supports retention, reduces cognitive load, and enables students to build on prior understanding. However, when repetition becomes excessive, it is experienced as redundant and demotivating, while insufficient or absent repetition leads to skill decay and difficulty engaging with more advanced material.

5.3 Horizontal Coherence - Switching as a Strategy: Resetting Motivation and Varying Engagement

This subsection examines how students experience switching between courses with differing content and cognitive demands. The results show that separating courses enables flexible allocation of attention and motivation, but also introduces switching-related mental overhead and uneven engagement across the curriculum. These were reflected in the categories and codes in Table 3.

Table 3: Coding Structure for Theme 3: Switching as a Strategy

Category	**Example Codes**
Course independence	task-switching, motivation resetting
Mindset shifting	mental partitioning, short-term reorientation cost
Selective engagement	variety increasing engagement, uneven study distribution, course prioritization

Participants generally described courses as independent, which requires them to shift mindsets when switching from studying one subject to another. This separation was perceived as a benefit, as students could move on from one subject to another when exhausted, with a participant explicitly emphasizing this mental reset: "whenever you got tired of writing tests and doing like just writing your lines per week, you can go to other linear algebra and start doing some matrix multiplications and stuff."

At the same time, switching requires some time for mental reorientation between different modes of thinking. Participants described this as a shift between distinct mindsets: "I guess there is some time in which you have to... You have to switch. You have to do the mental switch from, okay, I stopped being a competitive programmer, I have to go back to just studying the book. Or you have to become a developer now and do some data manipulation." However, this same participant follows this up with "I think the switch helps you more than it is detrimental." This is a perception shared by multiple participants, where they initially believe that this switch could be detrimental, but recognize that the benefits still outweigh the disadvantages, as it allows clearer boundaries between domains and reduces interference between concurrent topics.

Beyond the mental switching, variation across courses increases the likelihood that at least one course could keep them engaged. One student states that if "you got the quarter that you didn't like, that would be bad. Like, it would have been like people would drop out a lot. The fact that they're different means that at least one of them probably interests you."

However, this structure also reinforces selective allocation of effort. One participant described consistently prioritizing preferred courses, resulting in uneven distribution of study effort: "They're gonna pick their favorites, and they're gonna put more effort in their favorites always."

In summary, horizontal coherence is characterized by switching between largely independent courses, which students use to manage attention and motivation. This separation enables mental resetting and reduces interference across domains, though it incurs a short-term reorientation cost. The benefit of switching is generally considered to outweigh this overhead, particularly in a diverse curriculum structure. At the same time, variation across courses increases the likelihood of sustained interest but also encourages selective effort allocation, leading to uneven engagement across subjects.

6 Discussion and Conclusion

This study examined how final-year computer science students experience the coherence of their curriculum across both vertical and horizontal dimensions.

Vertically, students reported a mixed experience between cumulative knowledge progression and course independence. While foundational courses were perceived as supporting later learning, these connections were not always explicitly recognized, particularly when the curriculum emphasized breadth over depth.

In addition, the effectiveness of vertical coherence depended on the balance of reinforcement: appropriately revisited content supported retention and reduced cognitive load, whereas excessive repetition reduced engagement, and insufficient recurrence led to gaps that required self-directed compensation.

Horizontally, students largely experienced courses within the same period as independent. Rather than viewing this as a lack of coherence, they strategically used this separation to manage attention and motivation by switching between different types of tasks. While this variation supported engagement and reduced cognitive fatigue, it also encouraged selective effort allocation, resulting in an uneven distribution of focus across courses.

Overall, the results indicate that curriculum coherence is shaped not only by formal design but also by how students engage with progression, reinforcement, and variation across courses. The following discussion interprets these findings in relation to the existing literature and considers their implications for curriculum design.

6.1 Vertical Coherence - Coherence Through Knowledge Depth and Breadth

The results show that the progression of knowledge is especially important in spacing the mental burden of learning, as students acknowledge that skills and knowledge transfer between courses and help them understand deeper content. This means that related research into course progression, such as course-prerequisite networks (CPN) (Stavrinides & Zuev, 2023), remains fundamentally important for curriculum design.

However, participants also expressed a distinct disconnect between courses. They believe this is necessary to explore the breadth of options in the field during the bachelor's program, rather than specializing in a single discipline. In existing literature, Malamud (2010) argues that later specialization results in students finding jobs that are a better fit for them early on. In relation to this study, the results imply that students in computer science are aware of this benefit and are actively exploring their options to ensure their careers align with their interests. It also implies the need for curricula with breadth and depth, as the student body is heterogeneous with its needs (Malamud, 2010).

6.2 Vertical Coherence - Supporting New Content: Getting the Right Amount of Reinforcement

This study builds on Masters and Gibbs' (2007) research into how students engage with repeated content in a *spiral curriculum*. While spiral curricula focus narrowly on students who intentionally revisit official prior coursework, this study takes a broader perspective by evaluating how students revise as a whole. Consequently, the findings reveal that, in addition to the resources available in the curriculum, students use external sources when information is still missing. Given the findings that this learning may not be effective, courses should be designed with adequate support or explicit connections to prior courses.

Students may experience the *expertise reversal effect* due to excessive redundancy, a phenomenon in which the effectiveness of reinforcement reverses as learners' prior knowledge increases (Kalyuga, 2007). The results seem to support this and imply the need to reconsider how much emphasis is needed on some reinforcement; however, this should be taken as students' perceptions of the past, as they may have forgotten what they learned, mistaking it for redundancy.

6.3 Horizontal Coherence - Switching as a Strategy: Resetting Motivation and Varying Engagement

Students understand the effect of coherence through the benefit of resetting motivation by task switching, which is similar to how existing research conflates interleaved learning with spaced learning (Chen et al., 2021). Interleaved learning involves switching between courses while studying, and spaced learning involves taking breaks between studying. This means that computer science students may mistake interleaving for spaced learning, which Chen et al. (2021) argue should be viewed separately, as this misconception causes incorrect causal explanations in the literature they examined.

This study also builds on the paper by Jansen et al. (2016), which claims that higher interest in a course correlates with higher grades in that course. Naturally, the increased engagement students reported, driven by their interest in specific fields, supports this and emphasizes the importance of course variety to enable it. However, they also provide time management as a possible reason why other subjects receive comparatively lower grades.

6.4 Conclusion and Limitations

This study investigated how computer science and engineering students at TU Delft experience horizontal (concurrent) and vertical (sequential) curriculum coherence.

Firstly, it revealed that students understand that a coherent curriculum needs a balance between academic depth and breadth to meet the needs of the Bachelor's program. Secondly, students experience a coherent program when repetition is covered effectively; too much repetition causes them to disengage, while too little leaves gaps in their knowledge. Lastly, independence between parallel courses was perceived to support curriculum design, as it allows them to combat fatigue through task-switching.

The main limitation of the study is its scope: interviewing only six participants at the same university, discipline, and education level means that results about the breadth of the field may not apply, alongside other potential program-specific properties. Additionally, as this study is limited to how students experience coherence, the significance of this may be presented disproportionately compared to other aspects of the curriculum, such as individual course structure, workload, and complexity.

Future work investigating other fields, education levels, or scopes may further extend the validity of this study into a much wider range. Otherwise, studies on the significance of course structure and its coherence may further emphasize its importance.

References

Adams, W. (2015, August). Conducting semi-structured interviews. https://doi.org/10.1002/9781119171386.ch19

Betancur, L., Rottman, B. M., Votruba-Drzal, E., & Schunn, C. (2019). Analytical assessment of course sequencing: The case of methodological courses in psychology. *Journal of Educational Psychology*, *111*, 91–103. https://doi.org/10.1037/edu0000269

Braun, V., & Clarke, V. (2022). *Thematic analysis* (A. Maher & E. Carter, Eds.). Sage Publications Ltd.

Chen, O., Paas, F., & Sweller, J. (2021, December). Spacing and interleaving effects require distinct theoretical bases: A systematic review testing the cognitive load and discriminative-contrast hypotheses. https://doi.org/10.1007/s10648-021-09613-w

Fay, J. R., Newton, C., & Budge, S. T. (2021). Achieving curricular coherence in complex higher educational systems: Considering the human element in transformational change. *International Journal of Teaching and Learning in Higher Education 2021*, *33*, 23–33. http://www.isetl.org/ijtlhe/

Jansen, M., Lüdtke, O., & Schroeders, U. (2016). Evidence for a positive relation between interest and achievement: Examining between-person and within-person variation in five domains. *Contemporary Educational Psychology*, *46*, 116–127. https://doi.org/https://doi.org/10.1016/j.cedpsych.2016.05.004

Jin, H., Mikeska, J. N., Hokayem, H., & Mavronikolas, E. (2019). Toward coherence in curriculum, instruction, and assessment: A review of learning progression literature. *Science Education*, *103*, 1206–1234. https://doi.org/10.1002/sce.21525

Kalyuga, S. (2007). Expertise reversal effect and its implications for learner-tailored instruction. *Educational Psychology Review*, *19*, 509–539. https://doi.org/10.1007/s10648-007-9054-3

Lafleur, A., Rousseau-Gagnon, M., Côté-Maheux, M., Tremblay-Laroche, D., Cotret, P. R. D., & Caumartin, Y. (2021). Three weeks of team-based leaning do not overload undergraduate students. *Medical Science Educator*, *31*, 1369–1378. https://doi.org/10.1007/s40670-021-01314-x

Loder, A. K. F., Brandweiner, A. C., & de Oliveira Wood, G. M. (2025). Parallel enrollments: Associations between university student life and performance. *Cogent Education*, *12*. https://doi.org/10.1080/2331186X.2025.2474280

Malamud, O. (2010, April). *Breadth vs. depth: The timing of specialization in higher education* (Working Paper No. 15943). National Bureau of Economic Research. https://doi.org/10.3386/w15943

Masters, K., & Gibbs, T. (2007). The spiral curriculum: Implications for online learning. *BMC Medical Education*, *7*. https://doi.org/10.1186/1472-6920-7-52

Morales-Doyle, D. (2018). Students as curriculum critics: Standpoints with respect to relevance, goals, and science. *Journal of Research in Science Teaching*, *55*, 749–773. https://doi.org/10.1002/tea.21438

Newmann, F. M., Smith, B., Allensworth, E., & Bryk, A. S. (2001). Instructional program coherence: What it is and why it should guide school improvement policy. *Educational Evaluation and Policy Analysis*, *23*, 297–321. http://www.jstor.org/stable/3594132

Nguyen, H. Q. A., & Dao, N. A. D. (2025). Sequencing research writing and research methodology courses: Implications from students' course evaluation. *International Journal of TESOL & Education*, *5*, 48–66. https://doi.org/10.54855/ijte.25544

Schmidt, W. H., Wang, H. C., & McKnight, C. C. (2005). Curriculum coherence: An examination of us mathematics and science content standards from an international perspective. *Journal of Curriculum Studies*, *37*, 525–559. https://doi.org/10.1080/0022027042000294682

Stavrinides, P., & Zuev, K. M. (2023). Course-prerequisite networks for analyzing and understanding academic curricula. *Applied Network Science*, *8*. https://doi.org/10.1007/s41109-023-00543-w

Thijs, A., & van den Akker, J. (2009). *Curriculum in development*. SLO, Nertherlands Institute for Curriculum Development.

Wang, E. L., Kaufman, J. H., Lee, S., Kim, B., & Opfer, V. D. (2024). Research report instructional system coherence a scoping literature review. *Rand*. https://doi.org/ https://doi.org/10.7249/RRA279-5

A Appendix: Interview Guide

A.1 Pre-Interview

Thank you for your time! My name is Noe, and I'm researching how students experience the coherence of their curriculum and how it affects their learning. There are no right or wrong answers; I am simply interested in your experiences and perspectives. Before we begin, could you please confirm that the curriculum in front of you is correct? Please read the consent form carefully and sign it once you have done so. Now, with your permission, I will be recording this interview for transcription.

A.2 Interview Start

- Could you tell me more about what you like within the field?
- Which courses do you feel strong in?
- With which courses did you struggle the most?

A.2.1 Vertical Coherence

Let's move on to the first topic, which is about how sequential courses build onto each other.

- Can you think of a course that helped you in a course after it?
  - Can you describe what specifically helped you?
  - How did that affect your learning?
- Can you think of topics that were repeated unnecessarily? How did that affect the rest of the course for you?
- How about a case where repeating a topic helped? Why was the repetition useful to you?

- Can you describe a situation where you were missing prior skills or knowledge for a course?
  - How did you make up for it?
  - How did that impact your understanding or performance?
- Do you have anything else to say about the sequencing of the courses?

A.2.2 Horizontal Coherence

You also have 3 courses running at the same time each quarter.

- Did courses ever overlap in terms of content or skills within the same quarter?
  - If yes, could you name some examples?
  - If not, are they generally different from each other?
- How does the overlap/difference between courses affect your learning?
  - Does the overlap support your understanding of the topic?
  - Does the overlap between courses interfere with your understanding of the topic?
  - Do the differences between courses interfere with each other?
  - Does the difference support the other course?
- Is there anything else you would like to say about courses running in parallel?

A.3 Wrapping Up

That's it for this interview. Are there any questions you would like to ask me, or anything else you would like to say?