Knowledge integration matrix

Surfacing multi-, inter-, and transdisciplinary integration in CBL courses

TU/e CBL Toolkit · Teaching Resource

Level	LOW Parallel working	MEDIUM Active exchange	HIGH Co-creation
What integration might look like	Disciplines appear side by side. Students see multiple perspectives but do not yet combine them. Each has its own logic, language, and output.	Students and other stakeholders in and outside of the classroom actively draw on multiple disciplines to make progress. Connections are explicit.	Students and stakeholders outside the classroom jointly define the problem, negotiate whose knowledge counts, and make decisions together throughout. The boundaries between "student", "researcher" and "partner" are intentionally blurred.
Desired student behaviour	• Identify and articulate their own disciplinary boundaries and expertise • Notice and describe differences between disciplines without yet combining them • Use disciplinary terms accurately within their own field • Work in parallel with other disciplines and compile results • Reflect on what their own discipline contributed *(see the rubric below)*	• Recognise different disciplinary starting points and show humility about their own limits • Build a shared language and negotiate meaning across disciplines • Ask questions that genuinely require another discipline's input • Identify, name, and work through disciplinary tensions productively • Produce outputs where disciplinary contributions are visibly interconnected • Reflect on specific moments of friction and explain why they occurred *(see the rubric below)*	• Reframe the problem itself using insights from across disciplines and from partners • Treat practitioner and lived-experience knowledge as equal to academic sources • Co-produce outputs whose form and content were shaped by a number of academic and extra academic stakeholders on equal footing • Identify whose knowledge or perspective was excluded and reflect on the consequences • Point to a specific belief or assumption they no longer hold after the collaboration *(see the rubric below)*
Activities to facilitate integration	• Perspective-taking exercises (e.g. Exchanging Perspectives exercise) • Discipline introduction panels • Cross-disciplinary dialogues (e.g. Constructive Conversations)	• Concept mapping across disciplines (e.g. Experiencing Interdisciplinarity, Travelling Concepts exercises) • Jigsaw learning groups (e.g. Jigsaw classroom concept) • Boundary objects (shared artefacts) as a part of the expected output • Stakeholder mapping	• Co-designing sessions with external partners (e.g. Co-Designing Transition Experiments) • Living lab immersions • Boundary crossing workshops • System thinking workshops (e.g. Systems Thinking teaching resources) • Reflective portfolios on integration

(Desired) Student behaviour framework

This is a single unified framework. Each row covers one indicator of knowledge integration across three levels, so a teacher or a tutor can see the full progression in one view and observe where a team currently sits. This can be used formatively (to give feedback mid-project) or summatively (to evaluate a final output?). Not every indicator will be relevant for every type of the course (depending on its goal and the desired level of integration to be achieved) or at every stage of a student teams project.

The six dimensions of integration at a glance

#	Dimension	What it captures and why it matters
A	**Language & vocabulary**	How students use, adapt, and negotiate disciplinary and shared language, including what questions they ask. Repko & Szostak (2021) identify concept redefinition and shared vocabulary as the core mechanism of common ground construction.
B	**Team behaviour**	How the team actually works together and it is the social and organisational face of integration. Klein (2008) identifies the interaction of social and cognitive factors as one of seven generic evaluation principles. Parallel working (Low), active exchange (Medium), and co-creation (High) represent qualitatively different collaboration modes. Disciplinary humility is included here because it is a behavioural disposition relevant to team work.
C	**Disciplinary grounding**	The depth and accuracy of each discipline's contribution, and the legitimacy of the knowledge sources drawn upon. Boix Mansilla (2009) establishes grounding as a prerequisite for integration: shallow inputs produce shallow synthesis. At High level, Hirsch Hadorn et al. (2008) add that practitioner and lived-experience knowledge must be treated as epistemically equal to academic knowledge.
D	**Produced outputs**	What the team actually makes together, and what that product reveals about depth of integration. Observable in any tangible deliverable: artefact, prototype, model, report, design, policy brief. Star & Griesemer's (1989) boundary object indicator makes integration physically visible and assessable. At High level, the output is co-produced with partners and has value or function beyond the course.
E	**Purposefulness**	Whether and how students own and shape the integrative goal. Boix Mansilla & Duraisingh (2007) treat purposefulness as a distinct, assessable dimension: students must be able to say why integration is needed and toward what end (and how). At Low level, the brief is given; at Medium, the team negotiates it; at High, the purpose is co-defined with partners and may evolve during the project (Defila & Di Giulio, 2015). A recurring challenge in interdisciplinary and transdisciplinary engineering education is that learning goals remain vague, phrased as broad competencies (Van den Beemt, MacLeod & Van der Veen, 2020). Purposefulness is the dimension that counteracts this: it asks whether students can articulate a specific, discipline-requiring reason for the integration they are doing.
F	**Critical awareness**	Metacognitive reflection on the integration process itself; not on the content, but on what integrating revealed and transformed. Boix Mansilla (2009) treats this as a fourth distinct dimension. Students move from reflecting as disciplinarians (Low) to reflecting on the process of integration (Medium) to reflecting on what new knowledge emerged and whose knowledge was centred or excluded (High). We also consider Engeström's (1987) learning surprises here, as the most observable signal of genuine expansive learning.

(Team-based) knowledge integration behaviour indicators matrix

These indicators are not exhaustive, but they offer a direction: a set of observable signs to look for when expecting knowledge integration from student teams. Use the matrix to set realistic course goals, to identify where a team needs support, or as a self-observation tool for teams and coaches alike. It is a starting point for a conversation, not a checklist.

Dimension	Indicator	LOW level of integration Multidisciplinary	MEDIUM level of integration Interdisciplinary (narrow and/or broad)	HIGH level of integration Transdisciplinary
A. Language & vocabulary				
A. Language & vocabulary	**A1. Use of disciplinary terms** Boix Mansilla et al. (2009): disciplinary grounding; Repko & Szostak (2021): Step 3	Uses technical terms from own discipline without defining them for teammates.	Pauses to define disciplinary terms when they cause confusion.	Switches registers mid-conversation without prompting, able to differentiate and adapt language (speaks engineering to the engineer, plain language to the partner, policy language in the brief).
A. Language & vocabulary	**A2. Building shared language** Repko & Szostak (2021): Steps 7–8: creating common ground through concept redefinition	No shared glossary, concept map, or written definition of terms exists. Repeated miscommunications in meetings are not addressed, team moves on without resolving them.	Team has produced a shared glossary or concept map that all disciplines have contributed to. When a clash in meaning surfaces, the team stops and negotiates. Glossary is updated as work progresses.	Glossary or shared framework includes terms that came from partners or practitioners, not just academic disciplines.
B. Team behaviour				
B. Team behaviour	**B1. Working mode** Klein (2008): interaction of social and cognitive factors; Defila & Di Giulio (2015): team consensus	Team divides tasks by discipline at the start and only reconvenes to discuss and compile results. Individual sections are written independently. A team member can complete their work without having a clear understanding of what others are doing.	Team members routinely cross-reference and interconnect their work. Meetings are used to negotiate content, not just to exchange updates. One discipline's output visibly changes another's.	External partners are present in or directly shape working sessions, not just presentations. Partner input might change a decision the team had already made. Meeting notes show partner contributions alongside student contributions. Preferably, an external partner is a lifelong learning : a part of a team.
B. Team behaviour	**B2. Handling of difference and tension** Repko & Szostak (2021): Step 7: identifying conflicts and locating their sources	When two disciplines reach different conclusions, the team either picks one or presents both without engaging the difference.	When a conflict surfaces, the team names it explicitly and traces it to its source. This is written down and carefully considered. The conflict is not resolved by majority vote.	A documented moment in project log, portfolio, or meeting notes where a disciplinary or stakeholder conflict changed the direction of the project. The team can point to a specific decision that was reversed or reframed because of the tension.

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C. Disciplinary grounding				
C. Disciplinary grounding	**C1. Disciplinary humility** Tripp & Shortlidge (2019): disciplinary humility; Boix Mansilla & Duraisingh (2007): grounding	Students can articulate what their own discipline does, what its core concepts and methods are, and where its boundaries lie. They see themselves as a disciplinarian	Students recognise that their discipline's framing is not the only valid one. They explicitly name what their discipline cannot answer and actively defer to another discipline to fill the gap.	Students defer to practitioner or lived-experience knowledge, not just to another academic discipline in a way that visibly changes the team's position or direction.
C. Disciplinary grounding	**C2. Range of knowledge sources** Hirsch Hadorn et al. (2008): systems, target, and transformative knowledge types	References and sources are exclusively academic. Practitioner reports, field data, partner documents, or lived-experience accounts are absent from the analysis, or mentioned only in passing without being integrated.	Output cites and analyses both academic sources and practitioner or field-based sources. A practitioner's perspective is quoted or paraphrased and treated as evidence, not just as context.	Partner or practitioner knowledge appears as a co-equal source alongside academic literature: cited, analysed, and used to challenge or qualify academic claims.
D. Produced outputs				
D. Produced outputs	**D2. Shared artefact (boundary object)** Star & Griesemer (1989); Akkerman & Bakker (2011): boundary objects	No shared comprehensive artefact exists beyond a compiled report. Or: a shared template was used, but each discipline filled in their own section without negotiating the content with others.	Team can point to a specific artefact (a diagram, prototype, model, dataset, design, or system map) that all disciplines have physically worked on and modified. The artefact has been revised based on cross-disciplinary feedback.	The artefact has been reviewed, tested, or used by an external partner. Partner feedback has led to a documented revision. The artefact exists outside the course. It might be already in use by, or has been handed to, a partner organisation.
D. Produced outputs	**D3. Novelty of the output** Bergmann et al. (2005): TD quality; Boix Mansilla (2009): cognitive advancement; Klein (2008): effectiveness and impact	Output is a summary or application of existing knowledge. Reading the output, a disciplinary expert would find nothing they did not already know. The conclusion could have been written by a single discipline.	Output contains at least one claim, finding, or recommendation that is new, something that required combining disciplines to produce. The students and the teacher can identify the novelty of the produced output.	A partner, practitioner, or domain expert has confirmed (in writing or on record) that the output contains something they did not know, or that changes how they will approach the problem. The output has a life beyond the course.

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E. Purposefulness				
E. Purposefulness	**E1. Problem ownership & framing** Boix Mansilla & Duraisingh (2007): purposefulness; Engeström (1987): expansive learning	The teacher or the assignment decides the goal; students mainly follow the brief. Challenge/problem is already framed per discipline. *Ownership: teacher/assignment*	Students help negotiate or shape the goal within the team. Challenge/problem framed with direction, yet open enough to allow students to determine their own scope and purpose. *Ownership: students*	Students co-create the purpose together with external partners. The goal can change during the duration of the project/assignment. The purpose evolves as student learn more. Challenge/problem framing: completely open. Scope fully decided by students and societal partners. *Ownership: shared ownership = teacher, students, external partners.*
E. Purposefulness	**E2. Transferability of insight** Klein (2008): effectiveness and impact; Defila & Di Giulio (2015): diffusion beyond disciplinary boundaries	If written or presented: application to a specific case and/ or no claim about transferability. No attempt to identify principles that hold beyond this project.	If written or presented: Conclusion explicitly names one or more transferable principles with reasoning. The reasoning is visible and clear.	If written or presented: A partner, practitioner, or external audience has indicated they will use, adapt, or build on the output in a different context. Or: the team has been invited to present findings beyond the course (to a partner organisation, a conference, another team).
F. Critical awareness				
F. Critical awareness	**F1. Focus of reflection** Boix Mansilla et al. (2009): critical awareness; Utrecht four-stage model	If written or presented: Reflection describes what each discipline contributed. No reflection on what happened when these contributions met.	If written or presented: Reflection names a specific moment of friction or difficulty in the collaboration and analyses it. The analysis goes beyond describing what happened to explaining why.	If written or presented: Reflection identifies a specific belief or assumption the student held at the start of the project that they no longer hold. States what changed it and why.
F. Critical awareness	**F2. Awareness of limits & exclusions** Boix Mansilla (2007); Wickson et al. (2006): credibility and legitimacy	If written or presented: Limitations section / part is absent, there are only practical constraints mentioned. No acknowledgement of what the integrated output cannot explain or whom it does not represent.	If written or presented: Limitations are acknowledged, specific knowledge gaps. The student can say what a more complete integration would require.	If written or presented: Reflection explicitly names a group, perspective, or type of knowledge that was excluded from the collaboration and reflects on the consequence.

Dimension	Indicator	LOW level of integration Multidisciplinary	MEDIUM level of integration Interdisciplinary (narrow and/or broad)	HIGH level of integration Transdisciplinary
F. Critical awareness	**F3. Learning surprises** Engeström (1987): expansive learning: surprise as marker of zone of proximal development; Boix Mansilla (2010)	Reflection reports no surprises, or surprises are described as external (e.g. availability of data). No moment is identified where the student's understanding was genuinely disrupted.	Student describes a specific moment where they encountered something unexpected and explains how it changed what they did next. The pivot is visible in the project log or timeline.	A surprise, typically from a partner interaction, fundamentally contributed to the direction of the project. Student can point to a before/after.

Observer notes (for tutors and coaches)

Observer notes (for tutors and coaches)	Notes / evidence
Course / module	
Team / student(s)	
Date observed	
Observer	
Strongest evidence of integration in the session	
Key gap or tension to address	
Recommended next method or activity	

Indicator observation summary

Dimension	Indicator 1	Indicator 2	Indicator 3	Other comment
A. Language & vocabulary				
B. Team behaviour				
C. Disciplinary grounding				
D. Produced outputs				
E. Purposefulness				
F. Critical awareness				

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