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Cross-border collaboration to promote STEM education

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ABSTRACT

This study explores cross-border collaboration within the EUTech project, an educational initiative to promote STEM among lower secondary students in the Euregion Meuse-Rhine. The EUTech Award, central to this project, involved students in a three-phase design competition rooted in design- and inquiry-based learning. To support sustainable implementation and inform future partnerships, this study investigated the collaborative dynamics within a multidisciplinary project team via the theoretical lenses of boundary crossing (interprofessional learning) and team developmental space (intraprofessional learning). Data were collected across six partner meetings via storyline methodology, which captured participants' perceived moments of flow and friction. The results revealed that flow occurred more frequently and intensely than friction did. Flow emerged primarily from structured coordination, clear communication, and shared ownership, whereas friction arose from inconsistent information sharing, professional and cultural differences, and administrative burdens. All four boundary learning mechanisms (identification, coordination, reflection, and transformation) were observed, which developed iteratively throughout the project. The team's developmental space initially revealed a strong performance orientation (organising, goal setting) that was increasingly complemented by sense-making activities (dialoguing, reflecting), with frictions often prompting deeper reflection and learning. The findings highlight how the integration of boundary crossing and developmental space theories offers a nuanced and holistic understanding of inter- and intraprofessional collaboration in complex, cross-boundary settings. Practical implications include fostering mutual understanding, ensuring shared ownership, and proactively addressing boundary tensions. As scientific implication we suggest a new model for the combined process of intra- and interprofessional learning (I^2PL model).

Keywords: team developmental space, boundary crossing, cross-border collaboration, EUTech Award

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1 INTRODUCTION

The Euregion Meuse-Rhine (EMR), home to approximately four million inhabitants, encompasses five multilingual regions situated at the intersection of Belgium, the Netherlands, and Germany (see Figure 1). Its economy relies heavily on expertise in science, technology, engineering, and mathematics (STEM). However, for more than two decades, there has been a growing shortage of skilled STEM professionals (EMR2020 Steering Committee, 2020). An important reason for this problem is that few secondary school students choose STEM subjects, which reduces the number of students entering STEM pathways in vocational and higher education (Eurostat, 2017). To address this challenge, the EMR2020 Steering Committee (2020) underscores the necessity of cross-border, interdisciplinary collaboration between education and industry within the EMR. Therefore, several multidisciplinary Euregional partners have collaborated on the EUTech project, resulting in the creation of the Euregional Technology Award (EUTech Award): an educational STEM initiative for lower secondary school students focused on design- and inquiry-based learning.

Figure 1. Dutch, Belgian and German regions of the EMR[3]

The EUTech Award consists of three phases spread over approximately four months. In the first phase (Create your solution), students work in teams at their respective schools to

[3] The EMR encompasses the southern part of the Province of Dutch Limburg (blue), the Province of Belgian Limburg (light green), the Province of Liège (mid-green), the Region of Aachen (red), and the German-speaking Community of Belgium (dark green).

develop a technological design idea through inquiry, guided by human needs and inspired by a relevant theme such as sustainability or sport. They present their ideas on a digital platform, where public votes and the verdict of a professional jury together determine one winning class from each EMR region. In the second phase (Prove your skills), the winning classes take part in workshops and a quiz at an external venue to demonstrate their STEM competences. The class with the highest score wins the competition and is awarded the Euregional Technology Award. In the third phase (Make it happen), all classes collaborate with experts to bring their design ideas to life by developing prototypes. These prototypes are then physically presented to stakeholders and showcased in a public online exhibition.

The project, funded by the European Union (Interreg EMR210), was led by a multidisciplinary project team representing five core partners from three different EMR regions (see Table 1). This team was responsible for developing and organising the EUTech Award, recruiting participating schools, evaluating the project, and embedding it within education. Ultimately, 20 schools and nearly 600 students from across the EMR participated. Thus, the project is cross-border in both geography and stakeholder diversity, uniting people from various sectors, disciplines, and cultures, each with their own language, philosophy, and expertise.

Table 1. EUTech project main partners

Partner	Region	Description
Stimu-Leren Foundation	Province of Dutch Limburg	The foundation, founded by former science and technology professionals, aims to promote STEM among juveniles, in education and in society.
Fontys University of Applied Sciences	Province of Dutch Limburg	School of teacher training for secondary education in physics, and research group “Integrative education and boundary crossing”.
UCLL University of Applied Sciences	Province of Belgium Limburg	School of teacher training for secondary education in technology, and centre of expertise “Art of teaching”.
PXL STEM Academy	Province of Belgium Limburg	Educational institution that provides STEM education and training programs for juveniles and professionals.
Technifutur Centre de Competences	Province of Liège	Competence centre that develops and offers STEM-related (vocational) training courses to companies, job seekers, teachers and students.

In parallel with the implementation of the project, two studies were conducted. The first focused on the pedagogical design of the EUTech Award and its effects on students' attitudes towards

STEM (Authors, 2025). The second examined the collaboration process within the multidisciplinary team, which is central to this study. Research indicates that complex collaborative initiatives, such as the EUTech project, do not automatically lead to success (Bryson et al., 2006). Therefore, this study aimed to gain insight into the nature of collaboration within the EUTech project team, both to support sustainable future cooperation and implementation of the EUTech Award and to enable similar partnerships to benefit from our findings and to contribute to existing theories of collaboration.

2 THEORETICAL BACKGROUND

The complex nature of the EUTech project can be understood through the characteristics of the collaboration. On the one hand, joint development and learning occur within a clearly defined yet nontraditional educational context characterised as *intraprofessional learning* (Teheux et al., 2021). On the other hand, collaboration involves partners from diverse backgrounds, reflecting *interprofessional learning (*Roberts & Kumar, 2015). To examine both learning conditions and better understand collaborative dynamics, two theoretical frameworks are particularly suited: the theory of boundary crossing, which addresses the interprofessional nature of collaboration (Akkerman & Bakker, 2011; Gulikers & Oonk, 2016), and the theory of team developmental space, which captures the intraprofessional dimension (Derksen et al., 2019). These frameworks offer distinct yet complementary perspectives to explore how collaboration unfolds in a cross-boundary context such as the EMR.

2.1 Boundary crossing

Within the EUTech project, schools, companies, and knowledge institutions from the EMR collaborate across national borders, professions, disciplines, and cultures. This cooperation aims to foster mutual learning and develop new educational practices that enhance students' attitudes towards STEM. Akkerman and Bakker (2011) refer to this as boundary crossing: learning that occurs when individuals move between different sociocultural contexts (e.g., schools, workplaces, or communities), each with its own norms and perspectives. Differences in knowledge, culture, beliefs, and viewpoints can lead to tensions or discontinuities. While challenging, these moments also offer valuable learning opportunities.

2.1.1 Boundary practices, crossers and interactions

Boundary practices are locations and sociocultural activities where professionals from diverse backgrounds collaborate towards a shared goal (Akkerman & Bakker, 2011). Those navigating these settings are called *boundary crossers*, workers, or brokers. By transferring knowledge, tools, or perspectives across contexts, they unlock learning at the intersection of practices. *Boundary interactions* refer to exchanges between individuals from different domains, such as brainstorming sessions, interorganisational meetings, collaborative groups, case dialogues, and informal communication (Crasborn, 2018). Understanding these interactions and the role of

boundary crossers is key to fostering cross-boundary learning. In the EUTech project, the development and implementation of the EUTech Award exemplified a boundary practice. Project members (see Table 1) acted as boundary crossers, with monthly meetings forming central boundary interactions.

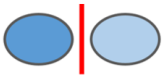
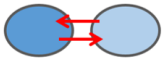
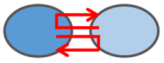
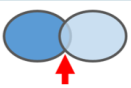
2.1.2 Boundary experiences as moments of flow or friction

When stakeholders collaborate within boundary practices, they do so on their own, often implicit, frames of reference, knowledge, and experience. If boundary-related actions falter or fall short, *boundary experiences* may arise: challenging moments that can cause misunderstandings, dilemmas, or conflicts as individuals move beyond their comfort zones. However, these experiences can also spark innovation, creativity, and mutual learning (Gulikers & Oonk, 2016). They manifest in moments of *flow* and *friction* as perceived by boundary crossers during interactions (Csikszentmihalyi, 2016). Flow refers to experiences that are enjoyable, constructive, motivating, or smooth. Friction, in contrast, involves negative emotions such as frustration, delay, or demotivation. These moments of flow and friction indicate how the collaboration evolves.

2.1.3 Boundary learning and learning mechanisms

Akkerman and Bakker (2011) define *boundary learning* as the learning that occurs when professionals engage across sociocultural boundaries by encountering and negotiating differing perspectives, beliefs, norms, and (background) knowledge. This type of learning arises because boundary practices often address complex, multifaceted challenges that cannot be resolved within the confines of a single domain. Confronted with unfamiliar or conflicting views, participants reflect on their assumptions, adapt practices, and cocreate new understandings. As such, boundary learning is both a response to complexity and a catalyst for innovation, mutual understanding, and professional growth.

Figure 2. Visualisation of the boundary crossing learning mechanisms[4]

Visualisation	Aim of the learning mechanism
	**1. Identification** Becoming aware of your own and others' expertise, assumptions, values, and principles, while recognising that your perspective may differ from those of others, is crucial for effective communication and collaboration.
	**2. Coordination** Deliberately building connections and collaborating to ensure project success, including identifying tools and procedures that foster effective teamwork. Good coordination aligns efforts, supports task division, and ensures mutual alignment.
	**3. Reflection** Stepping into others' shoes and considering matters from multiple perspectives allows participants to broaden their viewpoints, leading to a deeper understanding and fostering mutual respect.
	**4. Transformation** The integration of diverse perspectives and areas of expertise to generate new knowledge and outcomes at the intersection of existing practices, leading to novel insights and solutions that might not otherwise emerge.

[4] Adapted from "Towards a rubric for stimulating and evaluating sustainable learning," by J. Gulikers and C. Oonk, 2019, Sustainability, 11. Copyright 2019 by Judith Gulikers and Carla Oonk.

Gulikers and Oonk (2016) identified four learning mechanisms that describe how learning unfolds when individuals' cross boundaries between practices (see Figure 2): identification, coordination, reflection, and transformation. These interrelated processes do not follow a fixed sequence but may occur in varying orders or overlap, depending on the context. For example, coordination may precede identification, or failed coordination may trigger reflection.

2.2 Team developmental space

Collaboration in boundary practices often occurs in (project) teams: professionals working on tasks that are relatively new and require new knowledge or innovative integration of existing practices (Derksen et al., 2011). The success of such teams depends on team composition and collaboration. Effective teams combine the necessary knowledge, skills, and experience, but real value emerges through constructive interaction. To outperform individual members, teams must create a climate of information sharing and psychological safety. This fosters *team developmental space*: the social and mental space that arises through collaboration (Derksen et al., 2014), which is dynamic and context dependent.

2.2.1 Four activities

In an optimal developmental space, team members feel both safe and challenged to speak up. They trust each other, openly discuss differing views, and stay focused on shared goals within agreed boundaries. Teams create developmental space through four key activities (Derksen et al., 2014; see Figure 3):

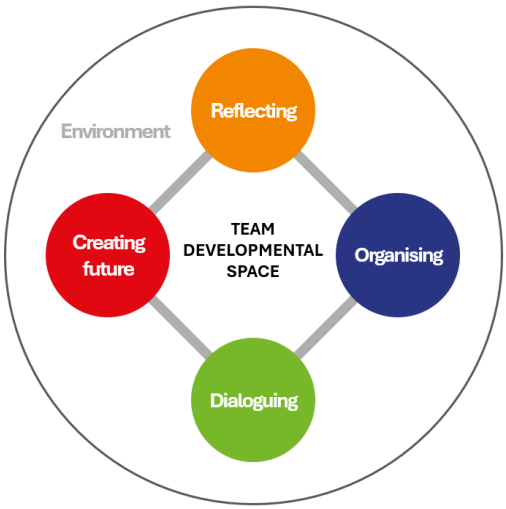
- ***Creating future*:** The team articulates a shared vision regarding its intended direction, objectives, and the problem it aims to address. Members have a clear understanding of the societal, organisational, and personal value they seek to contribute.

- ***Organising*:** The team establishes explicit agreements concerning responsibilities, timelines, and other constraints, which clarifies expectations and fosters a sense of shared ownership.

- ***Reflecting*:** The team integrates theoretical and practical insights and engages with diverse, at times conflicting, perspectives. Members systematically evaluate both team processes and outcomes.

- ***Dialoguing*:** The team engages in open, inquisitive dialogue by curiosity and mutual exploration. This communicative approach supports the coconstruction of shared understanding.

Figure 3. Model of developmental space for teams[5]



2.2.2 Paradoxical tension

The more effectively a team engages in the four key activities, the greater the developmental space experienced by its members, and the higher their satisfaction with the outcomes. This, however, presents a challenge, as the activities reflect two paradoxical yet equally necessary orientations (see Table 2). The *performance orientation* emphasises swift action and tangible results, whereas the *sense-making orientation* entails slowing down, broadening perspectives, and engaging in critical inquiry. Both are essential for high-quality outcomes, as they represent two sides of the same coin. Nevertheless, balancing these opposing approaches remains difficult for many teams (Smith & Lewis, 2011).

[5] Adapted from Goed teamwerk, by M. Derksen, 2021, Koninklijke Boom uitgevers. Copyright 2021 by M. Derksen.

Table 2. Tensions in the developmental space paradox[6]

Performance orientation	Sense-making orientation
Accelerate	Slow down
Result driven	Postpone the direction
Focusing	Broadening
Giving answers	Asking questions
Fixing	Enquiring
Looking forward	Looking back or standing still
Action oriented	Think oriented

3 GOALS AND RESEARCH QUESTIONS

This study aimed to explore collaboration within the multidisciplinary EUTech project team to support sustainable cooperation and the continued implementation of the EUTech Award. Additionally, the findings are intended to inform similar partnerships. Scientifically, the study contributes to collaboration theory by integrating interprofessional learning (boundary crossing) and intraprofessional learning (team space). The research was guided by the following three questions:

1. What moments of flow and friction do project members experience during project meetings?
2. How do the boundary crossing learning mechanisms manifest themselves in the project team's collaborative process?
3. What is the profile of the project team's developmental space, and how does this relate to the boundary crossing learning mechanisms?

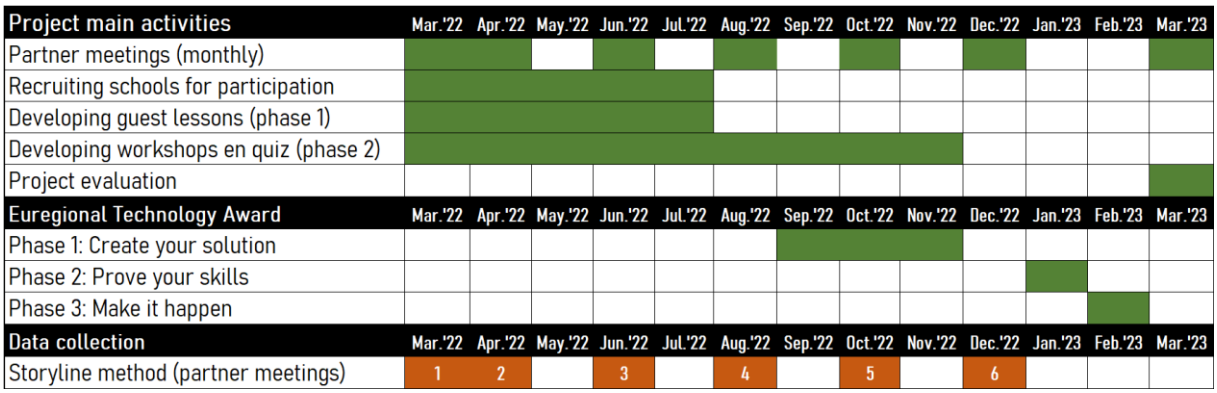
[6] Adapted from "Breaking the paradox: Understanding how teams create developmental space", by K. Derksen, R. J. Blomme, L. de Caluwé, J. Rupert, and R. J. Simons, 2019, Journal of Management Inquiry, 28(3), p. 368. https://doi.org/10.1177/1056492617718090. Copyright 2019 by Sage Publications.

4 METHODS

4.1 Participants and context

To support the development and implementation of the EUTech Award (boundary practice) that unfolded over approximately one year, seven general project meetings were organised, six of which were used for data collection (see Figure 4). These meetings constituted the primary boundary interactions within the project. In addition, smaller working group sessions were held to develop educational materials, guest lessons, and workshops. Each project meeting, lasting approximately two and a half hours, focused on exchange, communication, coordination and planning, feedback on materials, school recruitment strategies, accompanying research, and administrative and financial matters. Each EUTech partner (see Table 1) was represented in the project team by two professionals, who were often both present. On average, eight participants attended each meeting. One of the two representatives from Stimu-Leren Foundation, the project's lead partner, acted as the project leader and was responsible for monitoring substantive goals. An independent and experienced process manager supported the process and oversaw administrative and financial matters. The individually experienced moments of flow and friction (boundary experiences) during the project meetings (boundary interactions) provided a lens to understand how boundary learning occurred and how developmental space was created. These moments not only directly informed the first research question but also served as data for addressing the second and third questions.

Figure 4. Project planning and data collection



4.2 Data collection

To capture moments of flow and friction, the storyline method was employed (Beijaard et al., 1999). All project meetings were audio-recorded, and immediately after each meeting the participants individually completed a scaffolded digital storyline form. By collecting responses immediately after the meeting and through scaffolding, we aimed to reduce potential recall bias. Each 2.5-hour meeting was divided into five half-hour segments (start – early – middle – late – end). For each segment, the participants rated their perceived intensity of flow or friction on a five-point scale: strong friction (-4), some friction (-2), neutral (0), some flow (+2), and strong flow (+4). They then identified what they considered their most significant moment of flow and

their most significant moment of friction. For each selected moment, they were asked to briefly describe their experience via the following four questions:

- What content, topic, or issue was discussed during this moment of flow or friction?
- What happened during this moment of flow or friction?
- Why, from your perspective, was this a moment of flow or friction?
- To what extent, and/or why, did this moment of flow or friction come to an end?

4.3 Data preparation and analysis

Across the six meetings, an average of eight project members per meeting completed a total of 34 digital storyline forms, yielding a 71% response rate. These forms included 32 descriptions of individual moments of flow and 21 descriptions of friction. The participants showed substantial agreement in their perceived intensity of flow or friction, both in their scale ratings and in their responses to the open-ended questions. Although they used different words, their descriptions overlapped significantly and referred to the same core elements. This consistency allowed us to cluster the responses into 14 shared moments, eight of flow and six of friction, numbered chronologically in Table 3. This approach also reduces recall bias, as Meade et al. (2017) showed that shared recalls are not only more complete, but also more accurate. Following Beijaard et al. (1999), each shared moment was summarised into a narrative to support interpretation and address Research Question 1. The intensity of each moment was determined by averaging the individual ratings, resulting in positive scores for flow moments and negative scores for friction moments. To maximise objectivity in the transformation of individual responses into narratives, audio recordings were used during instances of ambiguity to prevent misinterpretation. Furthermore, the developed narratives were presented to the participants as a member check.

Table 3. Shared moments of flow and friction[7]

Meeting	Shared flow moment (number of individual descriptions)	Shared friction moment (number of individual descriptions)
Meeting 1 (March 2022)	1 (5), 3 (3)	2 (5)
Meeting 2 (April 2022)	4 (3), 6 (4)	5 (4)

[7] Across six meetings, eight shared moments of flow were identified (based on 32 individual descriptions), along with six shared moments of friction (based on 21 individual descriptions). These shared moments are chronologically numbered from 1-14. For example, during meeting 3 (June '22), a shared moment of flow occurred (number 8 in chronological order) based on five individual descriptions

Meeting 3 (June 2022)	8 (5)	7 (3)
Meeting 4 (August 2022)	9 (4)	10 (3)
Meeting 5 (October 2022)	12 (3)	11 (3)
Meeting 6 (December 2022)	14 (5)	13 (3)
Total	8 (32)	6 (21)

To explore how the boundary crossing learning mechanisms manifested within the project team's collaborative process (Research Question 2), the fourteen narratives were coded according to the four mechanisms presented in Figure 2: identification, coordination, reflection, and transformation. Unlike the relatively brief individual descriptions, the narratives provided a richer interpretation of the moments of flow and friction. This depth is essential for identifying learning mechanisms, which are often complex and embedded in subtle interactions, making them difficult to detect through surface-level observations alone. For example, the joint formulation of goals may appear collaborative, but only by examining the negotiation process can one assess whether participants genuinely consider one another's viewpoints or merely pursue their own agendas (Ryymin & Lamberg, 2022). Recognising whether partners are familiar with, appreciate, and understand each other's practices is crucial for identifying instances of boundary learning. To ensure interrater reliability, two researchers conducted the coding simultaneously until consensus was reached.

Unlike often complex learning mechanisms, activities related to team developmental space are more clearly defined and thus easier to identify. As Derksen et al. (2014) note, these activities are typically well delineated within team processes. For example, a participant's remark about "a constructive discussion aimed at reaching consensus" clearly indicates dialoguing. This approach enabled us to determine which dimensions of team developmental space predominantly influenced the moments of flow and friction and how these relate to the learning mechanisms (Research Question 3).

Figure 5 shows an example of a shared moment of flow, whereas Figure 6 presents a shared moment of friction. For both cases, three individual responses are shown to demonstrate how they contributed to the narrative and how they were subsequently coded.

Figure 5. Example of a shared moment of flow[8]

Participant	What was the topic of conversation?	What happened at that moment?	Why did you experience this as a moment of flow?	How did the moment come to an end?	Coding developmental space
1	Action plan for the coming months	An adjusted plan has been developed with clear actions and agreements for the coming months and meetings.	Clear agreements on actions and outcomes provide clarity and ensure a solid process.	It was the end of the meeting.	*Creating future, organising*
2	Project agreements for the future (coming months), prioritising	Together, we discussed the near future, focusing on what needs to be done, who is responsible, and when it should be delivered. This will be worked out, written down, and shared.	After a turbulent period marked by uncertainty, it is time to start thinking concretely about the future again. This provides guidance and has a motivating effect.	The fact that the agreements were clearly documented.	*Creating future, organising*
3	A plan with deadlines for the upcoming period	After a period of uncertainty (due to Covid-19), future planning can now take place. Clear agreements and actions are being documented to ensure that everyone knows what needs to be done and when.	The sense that progress can be made once again.	Taking minutes of the agreements and the end of the meeting.	*Creating future, organising*

Topic and learning mechanism	Narrative
Arrangements and action plan for coming months (run-up and implementation of EUTech Award). *Learning mechanism: coordination (2)*	Following flow moment 1, the end of the meeting provides clarity on the timeline for the coming months. Covid-19 had disrupted plans, but now the situation seems to be stabilising, allowing clarity to be provided on how and when implementation will take place. A new action plan with deadlines is greatly appreciated by the partners in this regard, as it provides guidance and certainty.

Figure 6. Example of a shared moment of friction[9]

Participant	What was the topic of conversation?	What happened at that moment?	Why did you experience this as a moment of flow?	How did the moment come to an end?	Coding developmental space
1	Approaching schools and securing commitment.	The suggestion was made to visit schools in person. Sending emails and waiting for a response does not seem to be effective.	Some partners apparently do not have time to visit schools in person and/or do not see the necessity of doing so. A new alignment is needed to develop an action plan.	By defining concrete actions (per region) for actively recruiting schools.	*Organising*
2	The number of schools approached and the method employed.	It became clear that there are significant regional differences: a single approach does not seem to be effective and is causing discussion.	Concerns that the required number of schools may not be reached. The partners are responsible for approaching the schools. One partner may organise this effectively, while another may not. This leads to misunderstanding.	Each partner explains the best approach for engaging schools, fostering mutual understanding. Each region develops its own strategy. We now better understand what works in each region and what differences exist.	*Reflecting*
3	Recruiting secondary schools in Flanders.	Discussing the idea of visiting schools in person to invite them to participate in the Award.	Communication with schools is ineffective and not conducted in the usual manner. There seems to be a lack of time to prioritise in-person school visits. Strong public relations are crucial, as there is only one opportunity to make an appeal to schools.	Through discussion, everyone gained a better understanding of each other's perspectives. Cultural differences are significant, and a 'one size fits all' approach doesn't work. This mutual understanding facilitated the exchange of tips and plans for effective recruitment.	*Dialoguing, organising*

Topic and learning mechanism	Narrative
Developing a strategic approach to engage schools in the EUTech Award. *Learning mechanisms: identification (1), coordination (2), reflection (3)*	Each partner has specific areas of expertise, and each regional context has its own identity. The ways in which schools could be approached for participation in the EUTech Award, and how partners view this, therefore appear to be points of discussion, especially given the low response rate from schools. What is the most effective approach, and can it be applied across all regions? Partners do not yet seem to be sufficiently familiar with each other's experiences and contexts. Through in-depth discussion, they gained a better understanding of each other's perspectives, differences of opinion became clearer and easier to comprehend, and consensus was reached on how to proceed.

[8] Meeting 1, March 2022, Moment 3 in Table 3. The sections marked in grey are part of the analysis.

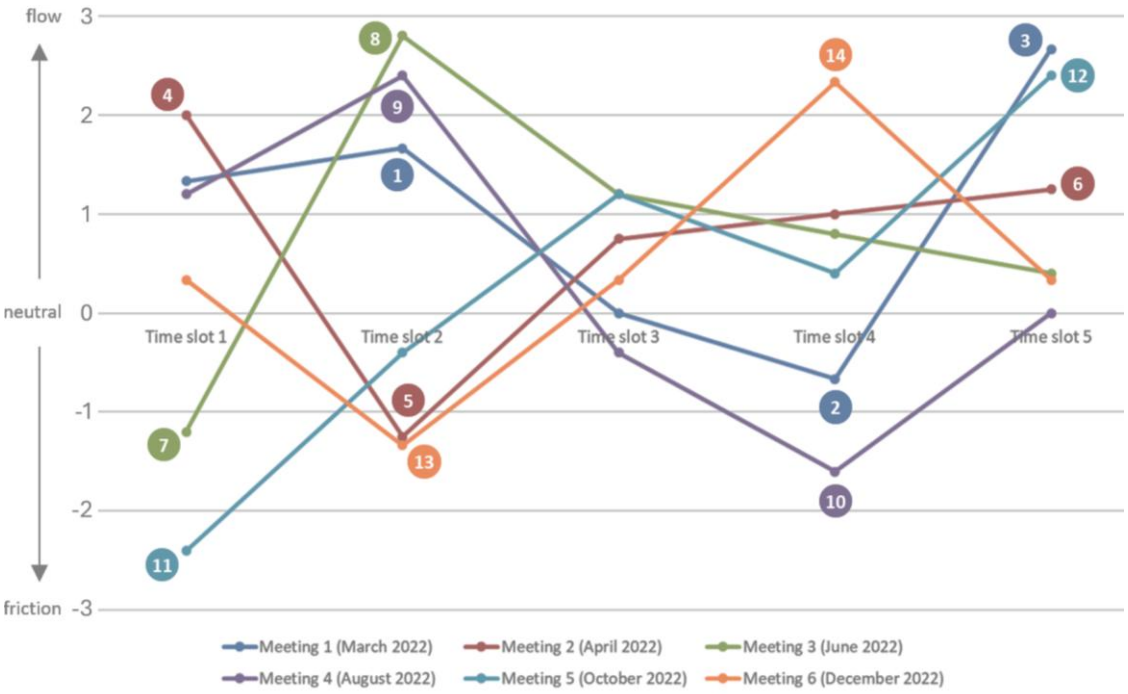
[9] Meeting 1, March 2022, Moment 2 in Table 3. The sections marked in grey are part of the analysis.

5 RESULTS

5.1 Perceived moments of flow and friction

Figure 7 shows the average perceived intensity of the eight shared moments of flow and six shared moments of friction that were experienced by the project team across six partner meetings. Based on the number of shared moments and the accompanying individual descriptions, moments of flow were clearly the majority, with approximately 60% of all individual responses referring to a moment of flow. Furthermore, if we interpret a rating around (-)1 as indicating slight flow or friction and a rating around or beyond (-)2 as indicating more substantial flow or friction, it becomes apparent that the moments of flow elicited a stronger experience than those of friction did.

Figure 7. Average perceived intensity of shared moments of flow and friction[10]



The shared flow moments in Figure 7, based on the full narratives in Appendix A, can be categorised as either contributing to a smooth process (process-related) or to achieving a result (product-related). Process-related moments mainly reflect a smooth workflow, including setting and keeping agreements, meeting deadlines, clear task distribution, shared ownership and commitment (to both one's own and others' work), and effective communication (not only in content and clarity but also in how information was shared and stored). Product-related flow

[10] Each time slot accounts for 30 minutes of the 2.5-hour meetings. The ratings of flow and friction are based on the average ratings of individual project members, who indicated their perceived intensity of flow or friction on a five-point scale: strong friction (-4), some friction (-2), neutral (0), some flow (+2), and strong flow (+4).

involved two key aspects. First, moments when project goals were achieved, such as the successful development of educational materials (e.g., guest lessons, workshops) or the successful implementation of EUTech Award activities (e.g., recruiting schools, delivering guest lessons, running workshops). Second, moments when project deliverables, particularly educational materials, were discussed in detail and fully understood by all project members. Given their generally higher intensity, product-related successes appear to amplify the experience of flow. Thus, a smooth process lays the groundwork, but shared success is the icing on the cake.

Moments of friction can be categorised into three main topics of which the first two topics are (strongly) related to triggers of flow.

- Process-related frictions resemble dynamics that can also facilitate flow, but here, they refer to issues that disrupt smooth project progress, such as missed appointments, unmet deadlines, and unclear objectives. However, two issues stand out in particular. First, timely and consistent sharing and archiving of information was lacking. Despite an agreement to use a shared cloud environment, team members continued to rely on various alternative methods, leading to lost or duplicated information, a lack of version control, and confusion. Second, over an extended period, partners focused primarily on project content ("What needs to be delivered?") and their individual roles while paying less attention to the collaborative process and shared responsibility. In addition, stakeholders such as schools, guest teachers, and companies often showed inconsistent levels of engagement, further hindering progress.
- Professional, cultural, and contextual differences caused friction, particularly regarding the didactic design of teaching materials. Regional variations in educational beliefs raised questions about what students should learn and how to achieve it effectively. Conflicting goals between educational and business representatives (e.g., ensuring high didactic quality versus maximising student reach) also contributed. Cultural differences, such as language barriers and diverse communication styles and organisational structures, further complicated collaboration. For instance, opinions differed on how best to recruit schools: through written or personal communication and via school management or directly with teachers. Despite these challenges, team diversity was crucial for effectively serving different regions. However, the partnership was imbalanced, as the German-speaking EMR regions were underrepresented, complicating efforts to engage stakeholders from those areas.
- Bureaucracy and administrative burden. Team members often perceived the funder's regulations as bureaucratic, time-consuming, and administratively burdensome, detracting from the core work.

5.2 Boundary crossing learning mechanisms

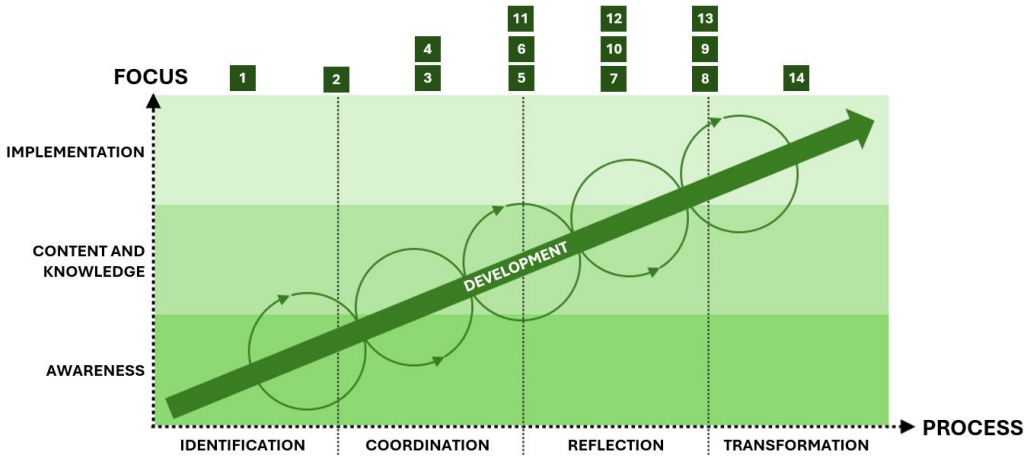
All four boundary learning mechanisms were evident in the project team's collaboration. Figure 8, which is based on the narratives in Appendix A, maps the fourteen chronologically numbered shared moments of flow and friction onto these mechanisms over time, showing shifts in the

team's average focus. Early shared moments are related primarily to identification and coordination, as shown in Figure 2. For example, at moment 1 (identification), one member noted, "There was clarity about the contributions each person could make." At moment 3 (coordination), another said, "We now have clear agreements on who is doing what." These experiences are crucial for building mutual understanding, reaching consensus, aligning efforts, and distributing tasks. Identification and coordination thus play a key role in developing awareness of individual roles and recognising partner differences, which supports effective planning and task allocation. This mutual understanding lays the foundation for focusing on project content and acquiring necessary knowledge.

Toward the end of the collaboration, shared moments of flow and friction increasingly centred on reflection and transformation. For example, at moment 12 (reflection), one participant described "a pleasant and constructive analysis of what we have achieved, and the professionalism of partners becoming visible." Participants progressively considered each other's perspectives and reflected on process evolution and potential improvements. At moments 8 and 9 (reflection and transformation), the team experienced flow through tangible progress in implementing the EUTech Award. Similarly, at moment 14 (transformation), a participant noted "an efficient follow-up trajectory, because everyone's expertise and expectations are now clear." These examples suggest that, as transformation gained prominence, the focus shifted toward practical implementation and future initiatives, such as developing a STEM teacher training programme for the EMR.

The emergence of learning mechanisms, however, is not strictly linear. Even as the focus shifts toward reflection and transformation (moments 5 to 9), coordination remains essential to align actions (moment 11). Thus, boundary learning is best understood as an iterative process in which all four learning mechanisms jointly ensure progress and mutual learning.

Figure 8. Learning mechanisms, participant focus, and positioning of flow and friction moments[11]



[11] Numbers 1 to 14 refer to the numbered shared moments of flow and friction in Table 3 and are positioned based on the narratives in Appendix A. If a moment is placed above a dotted line between two learning mechanisms, it concerns both adjacent learning mechanisms.

5.3 Team developmental space

Table 4 shows how individual moments of flow and friction, forming the basis of the narratives in Appendix A, are coded in relation to team developmental space. Figure 6 visualises the team's developmental space profile based on this data. The relative distribution of activities linked to developmental space across both flow and friction moments serves as an indicator.

Table 4. Distribution of coded activities for creating team developmental space[12]

Activity	Flow (*n*)	Flow (%)	Friction (*n*)	Friction (%)
Creating future	18	32	3	9
Organising	12	21	10	31
Reflecting	10	18	11	34
Dialoguing	16	29	8	25
Total	56	100	32	100

Figure 9. Team development space profile of the project team

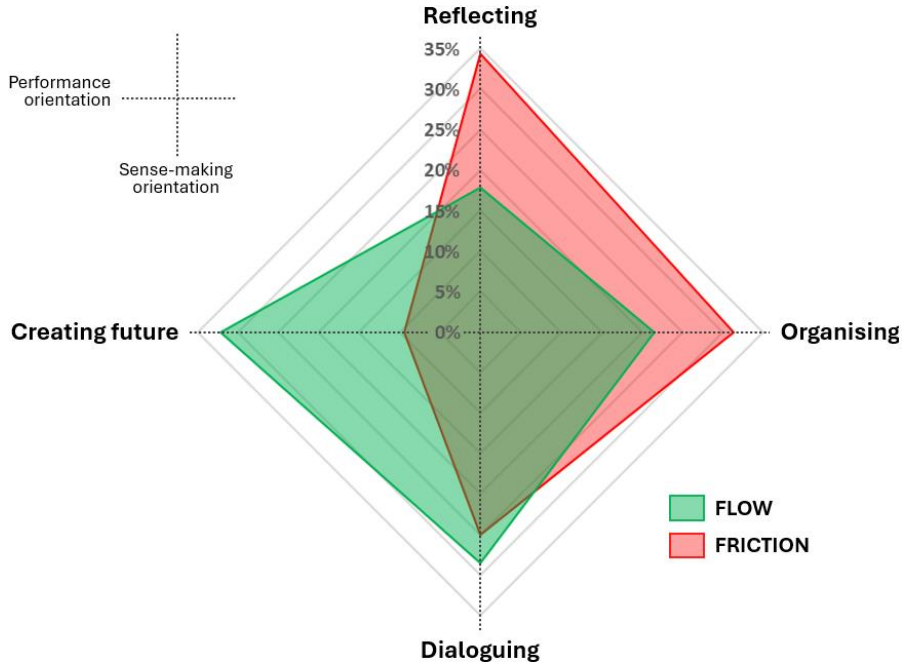


Figure 9 shows that all activities contributing to team developmental space were present, reflecting both performance and sense-making orientations. However, their contributions to the

[12] The data are based on the coding of 32 individual descriptions of moments of flow and 21 moments of friction. The relative distributions indicate the extent to which the various activities contributed to these moments.

flow and friction moments varied. Organising and dialoguing were clearly linked to both, but in different ways: in flow moments, they were more often associated with creating future, and in friction moments with reflecting. Thus, flow and friction are not distinguished by performance versus sense-making tensions but rather by differing emphases within both orientations.

The strong focus during flow moments on organising and creating future (performance orientation), combined with dialoguing (sense-making), reflects the team's emphasis on a smooth process and goal achievement, as discussed in Section 5.1. The emphasis on dialoguing also stemmed from the value participants placed on developing a shared understanding of underlying knowledge and insights. They referred to "jointly determining what we actually want to achieve" and "better understanding each other's perspectives by discussing the developed educational materials in depth." This aligns with the narratives in Appendix A, which highlight joint goal setting, task distribution, mutual understanding, and constructive communication as keys to effective collaboration.

In contrast, the friction profile in Figure 9 leans toward reflecting. Participants mentioned "insufficient attention to each other's interests and how this affected the process" and "a lack of shared responsibility." Reflecting entails improving collaboration by (re)acknowledging and addressing different perspectives, an aspect that proved challenging due to professional, cultural, and contextual differences. These factors intensified frictions, highlighting the need for timely reflection to support constructive collaboration.

6 CONCLUSION AND DISCUSSION

This study examined the complex, cross-border partnership of the EUTech project, which aimed to engage more lower secondary students in STEM education across the EMR by developing and implementing a Euregional design competition (EUTech Award). The research focused on the inter- and intraprofessional dynamics of collaboration, analysed through the theoretical lenses of boundary crossing and team developmental space, and guided by three research questions. Practically, the aim was to gain insight into the nature of this collaboration to inform the sustainability of future initiatives and support similar partnerships. Scientifically, the study explored the combined application of boundary crossing and team developmental space.

6.1 Answers to the research questions

The first research question explored the moments of flow and friction experienced by the project members during the project meetings. Project members more often reported moments of flow than friction during partner meetings, the main boundary interactions, and rated these experiences as more intense. Flow typically arises from smooth collaboration, marked by clear task division, timely and unambiguous communication, adherence to agreements, and a strong sense of shared ownership. These process-related factors fostered productive meetings. Flow peaked when the team achieved concrete milestones, such as developing or delivering educational activities, or when a shared understanding of underlying knowledge was reached.

Such outcome-related moments appeared to amplify the sense of shared success and engagement. Friction, although less prevalent, has emerged in several important areas. Process-related issues, such as inconsistent information sharing and a lack of attention to the collaborative process, disrupted team dynamics. Professional and cultural differences, especially in didactic beliefs and communication styles, sometimes hinder mutual understanding. An imbalance in regional representation poses additional challenges, particularly in engaging stakeholders from underrepresented German-speaking areas. Finally, administrative demands tied to funding were seen as bureaucratic and time-consuming, diverting attention from the project's core objectives.

The second question addressed how the boundary crossing learning mechanisms manifested themselves in the project team's collaborative process. All four boundary crossing learning mechanisms (identification, coordination, reflection, and transformation) were clearly present, each playing distinct yet interconnected roles in the team's collaboration. In the early phases, identification and coordination dominated, as members clarified roles, recognised differences, and aligned tasks to establish a shared foundation for collaboration and knowledge exchange. As the project progressed, reflection and transformation became more prominent, enabling critical evaluation, appreciation of diverse perspectives, and the implementation of practical outcomes such as the EUTech Award and prospective STEM teacher training initiatives. Notably, the mechanisms did not follow a linear sequence: even in later stages, coordination remained essential for maintaining alignment. This underscores the iterative and dynamic nature of boundary learning, with all four mechanisms continuously supporting mutual learning and collaborative progress.

The third question examined the profile of the project team's developmental space and its relation to the boundary crossing learning mechanisms. The project team's developmental space profile revealed a dynamic interplay between performance- and sense-making orientations, with all four developmental activities (creating future, organising, dialoguing, and reflecting) clearly present. Flow and friction were closely linked to the presence or absence of organising and dialoguing, indicating that process-related actions (e.g., planning, task division) supported collaboration, whereas dialoguing reflected the need for shared understanding and coconstruction of knowledge. Flow was further enhanced by setting shared goals and expectations (creating future). Friction, by contrast, was more often linked to insufficient reflection, particularly when tensions arose due to diverging expectations, varying levels of engagement, or cultural and professional differences. These frictions were not inherently negative; rather, they served as valuable triggers for collective learning and for recalibrating strategies, such as dialoguing, to restore flow.

The data show that intraprofessional learning (captured through the developmental space framework) and interprofessional learning (explained via boundary crossing mechanisms) are closely intertwined. Organising and creating future (performance orientation) provide a foundation for effective collaboration and help prevent process-related frictions. However, frictions more often stem from cultural, professional, and contextual differences that disrupt boundary crossing mechanisms. In such cases, dialoguing and reflecting (sense-making orientation) are vital for addressing tensions, reinforcing identification, coordination, and

reflection within the boundary crossing process. Moments of transformation are further enabled by shared success experiences, which in turn stimulate future-oriented actions (creating future). The team's developmental space thus acts as a driving force, allowing boundary crossing learning mechanisms to unfold and deepen over time.

6.2 Discussion

Overall, the findings suggest that successful collaboration was initially supported by a strong focus on process-related factors such as task division, communication, and goal setting. This aligns with Edmondson and Harvey (2018), who argue that early-stage cross-boundary teams benefit from clarity in roles, communication norms, and coordination routines to manage complexity and ambiguity. Sustainable intra- and interprofessional learning, however, emerged through the dynamic interplay between structured coordination (performance orientation) and meaning-making activities (sense-making orientation), particularly dialoguing and reflecting when navigating cultural, professional, and contextual differences. This reflects the view that boundary learning is iterative rather than linear, requiring negotiation between structured collaboration and interpretive work (Akkerman & Bakker, 2011). Ultimately, the team's developmental space acted as the engine for boundary crossing learning, reinforcing the statement of Bouw et al. (2019) that boundary learning deepens when actors experience both dialogic and action spaces.

The study also revealed that perceptions of flow are strongly associated with moments of success—not only the attainment of goals but also the comprehension of underlying knowledge or motives and the successful resolution of friction. This is consistent with findings by Keller and Landhäußer (2012), who argue that flow as a form of motivation stems not only from achieving goals but also from insight, understanding, and overcoming challenges. Flow and friction, often viewed as paradoxical, are thus closely intertwined, and both relate to the orientations of performance and sense-making. However, they cannot be strictly distinguished based on this paradox alone, as each involves varying degrees of both orientations in complex and dynamic ways. This aligns with the framework proposed by Miron-Spektor et al. (2018), who noted that experiences of flow and friction are shaped by multiple underlying paradoxes, such as autonomy versus control, exploration versus exploitation, individuality versus collaboration, and stability versus change. Thus, our strategy to map the team's developmental space by coding moments of friction and flow according to its paradoxical orientation proves suitable and may be applied to other paradoxical dynamics for deeper insight.

6.3 Implications

6.3.1 Practical implications

Based on the research, key implications for cross-border project teams can be outlined. Additionally, we highlight two instruments that help teams identify and visualise boundary crossing learning mechanisms and map and discuss their team development space efforts.

- Proactively engage with boundary experiences. Cultural, professional, and contextual differences are inherent in cross-border collaboration. Rather than merely acknowledging these boundaries, teams should explore them through structured reflection and dialogue, for example, by using the tool in Appendix B. What frictions are likely? What lessons emerged from earlier projects? Explicitly addressing these experiences can catalyse mutual learning.
- Align team activities with task demands. Ensure that all team development space orientations (creating future, organising, reflecting, and dialoguing) are meaningfully addressed in relation to the task, for example, by using the tool provided in Appendix C. Teams that focus mainly on planning and goal setting may overlook essential insights through reflection and dialoguing, which are critical for sustainable collaboration and learning.
- Engage external stakeholders from the beginning. While learning dynamics often emerge within the core project team, involving external stakeholders (e.g., schools, companies, funders) early on ensures shared understanding and relevance. Their perspectives can help calibrate expectations, prevent misalignment, and support the broader impact of the project.
- Cultivate shared responsibility. Effective collaboration requires more than delivering individual work packages. Team members should take joint ownership of the process, enabling better coordination, stronger cohesion, and collective transformation.
- Foster mutual learning through diversity. In addition to project objectives, teams should be encouraged to formulate explicit team learning goals. Collaboration across disciplines, roles, and backgrounds should be promoted to stimulate inductive, practice-based learning. For example, stimulate team members to work in heterogeneous subgroups on well-defined subtasks. This also strengthens shared ownership and enhances the team's ability to adapt to new challenges.
- Ensure structured communication and information sharing. A single, well-organised platform for communication and documentation reduces process frictions. Timely and accessible information exchange supports transparency, continuity, and collective reflection.

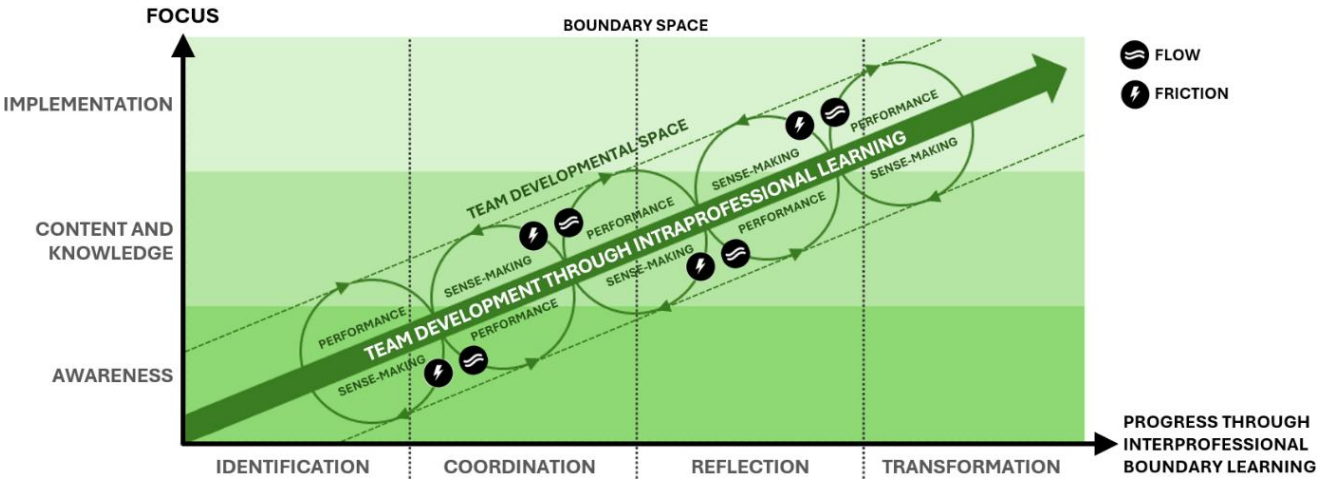
6.3.2 Scientific implications

The integration of boundary crossing and team developmental space models provides a more comprehensive and nuanced understanding of cross-boundary collaboration. While boundary crossing emphasises recognising and navigating cultural, professional, and contextual differences between collaborating partners (interprofessional learning), team developmental space highlights the internal dynamics of team development through its four components (creating future, organising, reflecting, and dialoguing), which are related primarily to intraprofessional learning. By combining these models, a more holistic framework emerges that

captures how diverse professional perspectives can be bridged while simultaneously developing the team's collective capacity.

Based on the findings, we propose a combined model that captures the interplay between inter- and intraprofessional learning. Figure 10, which we refer to as the Inter- and Intraprofessional Learning Model (I^2PL model), visualises how these two forms of learning interact. Building on Figure 8, the model illustrates that development at the meso level (boundary learning) is facilitated by learning at the micro level (team development). By actively engaging with moments of flow and friction, a dynamic process emerges, visualised by lemniscates, enabling the iterative engagement with sense-making activities and performance orientation. Slowing down during moments of friction and subjecting them to dialogue and reflection allows these frictions to be transformed into learning opportunities. In this way, friction becomes a stimulus for generating flow and fostering progress in the boundary space. As a result, the paradox of flow and friction supports collective learning, fosters shared responsibility, and contributes to the experience of success. Thus, moments of flow and friction function as energisers of the development process. By responding to them deliberately, synergy can emerge between intra- and interprofessional learning, as symbolised by the I-squared in the model's title. Within the boundary space, the effect of this synergy is reflected in a shift from identification to transformation, with the focus moving from awareness to implementation. To conclude, the complexity of the model reflects the real-world challenges inherent in complex partnerships. Further research is required to deepen understanding of the interactions among the elements of the I^2PL model and to evaluate the model's overall suitability.

Figure 10. The intra- and interprofessional learning model (I^2PL model)



6.4 Limitations and future research

This study has several limitations to consider. First, despite a relatively high response rate, the number of participants was small and limited to the EUTech project context, affecting generalisability. Future research should involve multiple teams across diverse (cross-border) projects to enhance external validity and identify transferable collaboration and learning patterns. Second, although the storyline method provided valuable insights into experiences of

flow and friction, and efforts were made to reduce recall bias, the data remain retrospective in nature. Without triangulation from sources such as videos, transcripts, or interviews, the analysis depth may be limited. Mixed-methods approaches could better validate and enrich the understanding of boundary experiences and team developmental space dynamics.

Third, although boundary-crossing learning mechanisms and team developmental space activities were explored jointly, their interrelations were primarily interpreted qualitatively, leading to the proposed I^2PL model. As previously noted, more research is needed, focusing on detailed process analyses and longitudinal studies (e.g., diary methods or real-time analytics), in order to gain a deeper understanding of the dynamic interplay among its elements, particularly during moments of flow and friction. Fourth, the focus on flow and friction as collaboration quality indicators was framed by the tension between performance and sense-making. Other paradoxes (e.g., autonomy versus control and exploration versus exploitation) suggested by Miron-Spektor et al. (2018) may also illuminate these experiences. Future research could explore these paradoxes to further clarify team development.

In summary, this study provides a fresh perspective on cross-border collaboration by integrating interprofessional and intraprofessional learning. While further empirical and theoretical work is needed to deepen our understanding of cross-boundary learning and team development, the findings show that meaningful collaboration across boundaries is rarely smooth. Yet, when teams embrace friction as a driver for learning, through reflection and sense-making, and view success as a moment of shared pride rather than individual achievement, cross-boundary learning becomes a catalyst for building bridges between institutions and people.

REFERENCES

Akkerman, S. F., & Bakker, A. (2011). Boundary crossing and boundary objects. *Review of Educational Research*, *81*(2), 132–169. https://doi.org/10.3102/0034654311404435

Akkerman, S., & Bakker, A. (2012). Het leerpotentieel van grenzen: Boundary crossing binnen en tussen organisaties. *Opleiding en Ontwikkeling*, *25*(1), 15-19.

Bakker, A., Zitter, I., Beausaert, S., & de Bruijn, E. (2016). *Tussen opleiding en beroepspraktijk: het potentieel van boundary crossing*. Koninklijke Van Gorcum.

Beijaard, D., Van Driel, J., & Verloop, N. (1999). Evaluation of story-line methodology in research on teachers' practical knowledge. *Studies in Educational Evaluation*, *25*(1), 47–62. https://doi.org/10.1016/S0191-491X(99)00009-7

Bouw, M., Zitter, I., & De Bruijn, E. (2019). Characteristics of learning in the boundary zone.

Vocations and Learning, 12(2), 217–240. https://doi.org/10.1007/s12186-018-9214-2

Bryson, J. M., Crosby, B. C., & Stone, M. M. (2006). The design and implementation of Cross-Sector

collaborations: Propositions from the literature. *Public administration review*, *66*, 44-55. https://doi.org/https://doi.org/10.1111/j.1540-6210.2006.00665.x

Crasborn, F. (2018). *Grensovergangen in de lerarenopleiding*. Inaugural lecture. Fontys Lerarenopleiding Sittard.

Csikszentmihalyi, M. (2016). *Flow and the foundations of positive psychology*. Springer.

https://doi.org/10.1007/978-94-017-9088-8

Derksen, K., de Caluwé, L., & Simons, R. J. (2011). Developmental space for groups working on innovation. *Human Resource Development International*, *14*(3), 253–271. https://doi.org/10.1080/13678868.2011.585060

Derksen, K., de Caluwé, L., Rupert, J., & Simons, R.-J. (2014). Assessing developmental space in teams. *Team Performance Management: An International Journal, 20*(7/8), 277–293. https://doi.org/10.1108/TPM-03-2014-0022

Derksen, K., Blomme, R. J., de Caluwé, L., Rupert, J., & Simons, R. J. (2019). Breaking the paradox:

Understanding how teams create developmental space. *Journal of Management Inquiry*, *28*(3), 366–380. https://doi.org/10.1177/1056492617718090

Derksen, K. (2021). *Goed teamwerk*. Koninklijke Boom uitgevers. https://www.boomportaal.nl/boek/9789462764088

Edmondson, A. C., & Harvey, J.-F. (2018). Cross-boundary teaming for innovation: Integrating

research on teams and knowledge in organizations. *Human Resource Management Review, 28*(4), 347–360. https://doi.org/10.1016/j.hrmr.2017.03.002

EMR2020 Steering Committee. (2020). *A future strategy for the Euregio Meuse-Rhine*. Provincie Limburg. https://issuu.com/dienst_europa/docs/20130069_prov_limb_ emr_2020 _plan_en.

Eurostat (2017). *Distribution of tertiary education graduates*. European Commission. https://ec.europa.eu/newsroom/rtd/items/680749/en

Gulikers, J., & Oonk, C. (2016). Boundary crossing in regioleren: Actief ondersteunen van student-

stakeholder samenwerking. In A. Bakker, I. Zitter, S. Beausaert, & E. de Bruijn (Eds.), *Tussen opleiding en beroepspraktijk: Het potentieel van boundary crossing* (pp. 226–246). Koninklijke Van Gorcum.

Gulikers, J., & Oonk, C. (2019). Towards a rubric for stimulating and evaluating sustainable learning. *Sustainability*, *11*(4), Article 969. https://doi.org/10.3390/su11040969

Keller, J., & Landhäußer, A. (2012). Flow and motivation in educational settings: Investigating the

role of interest and success experiences. *Learning and Instruction, 22*(5), 340–352. https://doi.org/10.1016/j.learninstruc.2012.04.002

Meade, M. L., Harris, C. B., Van Bergen, P., Sutton, J., & Barnier, A. J. (2017). *Collaborative*

Remembering: Theories, Research, and Applications. Oxford University Press. https://doi.org/10.1093/oso/9780198737865.001.0001

Miron-Spektor, E., Ingram, A., Keller, J., Smith, W. K., & Lewis, M. W. (2018). Microfoundations of

organizational paradox: The problem is how we think about the problem. *Academy of Management Journal, 61*(1), 26–45. https://doi.org/10.5465/amj.2015.0246

Roberts, C., & Kumar, K. (2015). *Student learning in interprofessional practice-based environments:*

What does theory say? BMC Medical Education, 15, Article 284. https://doi.org/10.1186/s12909-015-0492-1

Ryymin, E., & Lamberg, R. (2022). Facilitated boundary crossing learning in interdisciplinary

research teams. *The Learning Organization, 29*(4), 313–326. https://doi.org/10.1108/TLO-09-2020-0172

Smith, W. K., & Lewis, M. W. (2011). Toward a theory of paradox: A dynamic equilibrium model of organizing. *Academy of Management Review*, *36*(2), 381–403. https://doi.org/10.5465/amr.2009.0223

Teheux, O., Degryse, J., Mertens, F., & Deveugele, M. (2021). *Intraprofessional workplace learning*

in postgraduate medical education: A scoping review. BMC Medical Education, 21, Article 447. https://doi.org/10.1186/s12909-021-02905-3

APPENDIX A

Narratives belonging to moments of flow and friction

Table A1

Narratives belonging to moments of flow and friction

Moment	Topic, BC learning mechanisms and objects	Narrative
1 - flow	Progress on development of hybrid teaching materials for guest lessons in response to Covid-19. • BC learning mechanism: 1,2	After a long period of (partially) closed schools and cancelled events, due to Covid-19, the initiative is taken to create a hybrid version of guest lessons in case schools will be closed (again). In retrospect this turned out not to be necessary. However, partners state this decision gives a flow to the process, as uncertainty about implementation is removed. The response from partners shows that it is motivating to have a common goal (again) and to have more clarity on what each partner can/will contribute (in the near future). It is clear that (sufficient) future prospects encourage cooperation. Partners indicate that educational materials, which have to be developed, (will) play a central role in collaboration and (will) act as connecting elements, as a kind of common concern.
2 - friction	Developing a strategic approach to engage schools in the EUTech Award. • BC learning mechanism: 1,2,3	Each partner has specific areas of expertise, and each regional context has its own identity. The ways in which schools could be approached for participation in the EUTech Award, and how partners view this, therefore appear to be points of discussion, especially given the low response rate from schools. What is the most effective approach, and can it be applied across all regions? Partners do not yet seem to be sufficiently familiar with each other's experiences and contexts. Through in-depth discussion, they gained a better understanding of each other's perspectives, differences of opinion became clearer and easier to comprehend, and consensus was reached on how to proceed.
3 - flow	Arrangements and action plan for coming months (run-up and implementation of EUTech Award). • BC learning mechanism: 2	Following flow moment 1, the end of the meeting provides clarity on the timeline for the coming months. Covid-19 had disrupted plans, but now the situation seems to be stabilising, allowing clarity to be provided on how and when implementation will take place. A new action plan with deadlines is greatly appreciated by the partners in this regard, as it provides guidance and certainty.
4 - flow	[1] Exploring topics and sharing examples for use in the STEM toolbox. [2] Pushing back the date of the final event. • BC learning mechanism: 1,2,3	[1] Devising and developing educational STEM resources clearly seems to provide a stimulus. Partners enjoy being engaged in the primary task, sharing good examples, and seeing progress. Partners share a common interest in regard to education, despite also having partly different views. It seems that partners do know what they need from each other and what division of roles is desirable to achieve good results. [2] The decision to schedule the final event a month later gives breathing space, as partners are experiencing considerable time pressure.
5 - friction	[1] Required actions by the grant provider. [2] Different perceptions regarding pedagogical approach for guest lessons. • BC learning mechanism: 2,3	[1] The grantor demands quite a lot of administration and accountability, which (sometimes) seems frustrating. Some partners (occasionally) feel they are not engaged enough with the actual project content. Quite a lot of time is wasted on peripheral issues. [2] A discussion took place on the content of the guest lessons. In particular, about the investigation that students have to do during the second guest lesson. While pedagogically it is a strong element, in terms of feasibility it may seem difficult to implement. Finally, it is decided, based on educational arguments and project goals, to keep the investigation part, and to evaluate it afterwards.
6 - flow	[1] Presentation of ideas and (partly) developed workshops for the final event. [2] Commitment of schools to participate in the EUTech Award. • BC learning mechanism: 2,3	[1] Some (partial) realisations of workshops for the final event are presented, which are received enthusiastically. Partners indicate the presentations lead to valuable discussions that can reinforce quality. Partners also indicate a growing understanding of the chosen pedagogical approach, suitable for all regions. One partner notes it is becoming increasingly clear what the relationships are within the partnership and how this contributes to the quality achieved. It brings new insights and ideas. [2] School recruitment finally seems to be taking off, and more and more schools are signing up to participate, which is one of the project goals. Although the desired number has not yet been reached, the progress made is satisfactory.
7 - friction	[1] The purpose and function of the STEM toolbox. [2] Partners' use of the shared cloud storage, and uncertainty about the schedule and desired actions for the coming months. • BC learning mechanism: 2,3,4	[1] One of the project goals is to deliver a STEM toolbox. For some partners, it is unclear for whom this toolbox is intended, what the content and format should be, who should provide the content, and how it relates to the EUTech Award. One partner mentions that delivering high quality, accessible learning materials can only be achieved when preconditions are clear. [2] Partners use a shared cloud storage (online workplace), which is not structurally used/maintained. In addition, several documents circulate with schedules, desired actions, and so on. There seems to be a need for more (timely) information that is also complete and unambiguous, also because too often certain agreements and deadlines do not seem to be met.
8 - flow	[1] Promotional video for the EUTech Award. [2] Presentation of a new workshop for the final event. • BC learning mechanism: 3,4	[1] The new promotional film of the EUTech Award for schools is inspiring and motivating. One partner calls it a visual representation of what has been achieved together, and indicates that it can be a spin-off for sustainable implementation and new ideas. Concrete achievements give energy and fuel cooperation. [2] Once again, a developed workshop for the final event was presented. As with other workshops, this was received positively, and seen as motivating and a step forward.

9 - flow	Presentation of final learning materials for guest lessons (including teacher materials) and workshops for the final event. • BC learning mechanism: 2, 3,4	All educational materials for implementation of the EUTech Award, including supporting materials for teachers, are as good as finished and are presented and discussed in conjunction. One partner refers to it as an important milestone, necessary to ensure proper implementation and dissemination. Another partner mentions it is great to reach consensus, to understand each other, and to "speak the same language", despite regional differences.
10 - friction	[1] Lack of clarity on how and when the quality of developed educational materials will be assessed. [2] Confusion regarding schedules, deadlines, appointments and cloud storage. • BC learning mechanism: 2,3,4	[1] While it is important to have delivered some of the intended outputs together, it is also important to have/gain insight into the quality of implementation. What do efforts yield and what lessons can we learn from it? There seems to be a lack of clarity on how this will (should) be done, and how these insights will be brought to stakeholders and affect educational practice. For some of the partners, this discussion leads to frustration because, as mentioned by one partner, sustainable anchoring/implementation is not given enough attention. The friction is remedied by explicitly naming already planned actions (in the original project plan) and designating them in the process. [2] Again, the inadequate use of cloud storage comes up. Different means of communication are used for sharing information. This confuses information and creates lack of clarity about where (correct) information can be found.
11 - friction	Required actions by the grant provider: balance between project efforts and accountability to grantor. • BC learning mechanism(s): 2,3	The grant provider did a check on some basic agreements and requirements, such as the use of logos and mandatory information on websites. Some partners express dissatisfaction about this and mention (again) the large administrative burden. One partner mentions the term distrust in this context. Another partner had expected more substantive involvement and less bureaucracy. All in all, the involvement and context of the grant provider does not seem to be sufficiently understood and/or accepted.
12 - flow	Evaluation of the first guest lessons and reactions to the workshops developed for the final event. • BC learning mechanism: 3	The first guest lessons carried out, including a short training for teachers, are discussed. Overall, initial reactions and impressions are positive, which raises confidence and energy to move on. One partner indicates that when partners' professionalism is bearing fruit, they get committed and enthusiastic, which is a key requirement for success. The workshops for the final event are again mentioned as another example in this context. The expertise of the various partners is clearly recognised and valued, because partners stress the importance of each other's input. One partner indicates that the hybrid collaboration has certainly caused difficulties, but has also led to valuable insights and results.
13 - friction	Complexity of the online environment for sharing design ideas devised by students, as part of guest lessons. • BC learning mechanism: 2,3	After performing all guest lessons, there appears to be a problem with the second guest lesson. The online procedure students should use to upload and share their design ideas appears to be time consuming, not user-friendly and (unnecessarily) complex. This frustrates the process and distracts from the primary task and can have a negative impact. Two partners are surprised that the procedure was not reviewed by all partners in advance, and partners were not as vigilant as they should be. One partner indicates that this would not have been necessary if the procedure had been shared and discussed in advance. After all, there are valuable monthly partner meetings. The procedure will be reviewed for the near future.
14 - flow	Discussion on the status and progress of the project, and a potential follow-up project. BC learning mechanism: 3,4	With the final event and the end of the EUTech Award approaching, the progress and status of the process is discussed. Also discussed is a new (follow-up) project aimed at training (pre- and postservice) STEM teachers. Partners are clearly proud of what has been achieved, despite difficulties caused by Covid-19. Although points of improvement are mentioned, the positive remarks prevail. It is also indicated that more is needed to have a sustainable impact on educational practice. Reaching more schools and students, and introducing teachers to new didactics and pedagogies would truly add value. Therefore, a follow-up project might be an option. All in all, enthusiasm is visible, driven by experiences of success

Note. The numbers of moments of flow and friction are based on Table 3. The numbers of BC learning mechanisms are based on Figure 2: 1 = identification, 2 = coordination, 3 = reflection, and 4 = transformation.

APPENDIX B

Boundary crossing learning mechanism questionnaire

Table B1, adapted from Gullikers and Oonk (2016), provides a set of questions to identify boundary learning mechanisms during boundary practices.

Table B1

Boundary crossing learning mechanism questionnaire

Questions to identify the four boundary crossing learning mechanisms		
Learning mechanism	Purpose	Examples of questions to ask
Identification	Gaining insight into how different practices differ from or complement each other.	▪ What expertise do I bring? ▪ Which expertise am I missing in the context of this issue? ▪ Who are the relevant stakeholders? ▪ What is their knowledge, interest, and perspective? ▪ How do they relate to one another?
Coordination	Collaborating on addressing the issue, with a focus on efficient, side-by-side functioning.	▪ How can I approach and engage the various stakeholders? ▪ How can we communicate and collaborate effectively? ▪ What agreements do we make? ▪ Who can I involve for what?
Reflection	Learning to view one's own practice through the eyes of others. This involves defining and exchanging perspectives with the aim of mutual meaning-making and integrating diverse knowledge and expertise.	▪ What can we learn from one another? ▪ How can I ensure that others understand my perspective? ▪ What can I learn from others' perspectives?
Transformation	Occurs when new practices emerge. The outcome could not have been achieved without true collaboration and integration of different perspectives and desires.	▪ What is my vision for the new practice? ▪ How can we combine our knowledge, insights, and perspectives into an innovative yet feasible approach? ▪ How do I engage others in the new practice? ▪ How can I ensure that the new practice is implemented and followed up (sustained new practice)?

Note. Adapted from "Het waarderen van leren met partijen buiten de school," by J. Gulikers and C. Oonk, 2016, *OnderwijsInnovatie*, pp. 17–24. Copyright 2016 by J. Gulikers and C. Oonk.

APPENDIX C

Team developmental space questionnaire

The tool in Table C1, adapted from Derksen et al. (2014), is an instrument to map and discuss the team developmental space with team members.

Table C1

Team development space questionnaire

Questionnaire team developmental space					
How well do you think your team put the following statements into practice? **1 = not applied** **2 = applied to a limited extent** **3 = applied** **4 = applied to a great extent** **5 = applied to a very great extent**					
Dialoguing	1	2	3	4	5
01 We listened to everyone in the team.					
02 I felt appreciated for my contribution.					
03 We kept asking questions until we truly understood each other.					
04 I felt heard by the other team members.					
05 I felt invited to contribute.					
Organising	1	2	3	4	5
06 Our meeting was well-structured.					
07 We monitored the available resources (money and personnel).					
08 We stuck to the schedule.					
09 I knew exactly what was expected of me.					
10 We kept track of time.					
Reflecting	1	2	3	4	5
11 We stepped off the beaten track.					
12 We evaluated our collaboration.					
13 We engaged in discussion to find solutions.					
14 Differences of opinion helped us move forward.					
15 We came up with alternatives.					
Creating future	1	2	3	4	5
16 We had a clear goal in mind.					
17 All team members felt responsible for the outcome.					
18 We were focused on the result.					
19 Every team member was fully committed to the task.					
20 All team members supported the intended outcome.					

Note. Adapted from "Assessing developmental space in teams," by K. Derksen, L. de Caluwé, J. Rupert, and R.-J. Simons, 2014, *Team Performance Management: An International Journal*, *20*(7/8), 277–293. © 2014 by Emerald Group Publishing Limited.