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BY
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CV

Dan Jiang is a currently a PhD student at the UNESCO Center for Problem-Based Learning in Engineering Science and Sustainability (UCPBL Center), Department of Planning & Institute for Advanced Study in PBL, Aalborg University, Denmark. She obtained her Master degree in History of Education in 2018 from Beijing Normal University, China. She started her PhD in July 2020. Her PhD research focuses on the intercultural PBL context in engineering education, with a special focus on the adaptability and development of learner agency in such an environment. She also worked as a research assistant at the same time, focusing on student agency and engagement for sustainability in PBL. From 2021 to 2022, she joined a European-level project, SMART-ER Academy for the European Consortium of Innovative Universities (ECIU), where she collaborated with twelve European universities on completing a deliverable report.

ENGLISH SUMMARY

The importance of learner agency has gained increasing recognition in engineering education recently due to its potential to influence individuals' sense of professional identity and their decisions to continue their studies. Learner agency is a complex and dynamic system in which learners play active and intentional roles in their learning process. It also concerns the ability of learners to take ownership of their learning, make choices, set up goals, regulate their learning activities, and interact with their environment. Learner agency is aligned with the principles of PBL (problem- or project-based learning), which is a constructivist learning approach focusing on student-centered learning and active engagement. In a PBL context, engineering students work in small teams to deal with complex and real-life problems, identify gaps in their knowledge, and actively explore multiple sources of information and resources. However, ongoing global and social challenges require future engineers not only to deal with problems within their own disciplines, but also to develop intercultural competencies to address more complex social problems. It is thus necessary to delve deeper into how engineering students work within an intercultural PBL setting. Furthermore, it remains unclear how this setting contributes to the development of learner agency among students. This study therefore aims to explore students' views on the development of learner agency in an intercultural PBL setting by answering the following research questions:

RQ 1. What characteristics, challenges, and coping strategies of student intercultural team collaboration have been reported in engineering education research? (Paper 1)

RQ 2. How do engineering students perceive their development of learner agency and what are the factors influencing its development in an intercultural PBL environment (Paper 2)

RQ 3. What elements do engineering students consider important for supporting their development of learner agency in an intercultural PBL team? (Paper 3)

To answer these three research questions, three papers are included in this PhD thesis. Paper 1 adopts a systematic review approach to answer RQ 1. Analysis of 77 articles identifies several characteristics of student intercultural team collaboration, including team format, collaborating countries, level of collaboration, preparation for teamwork, learning goals, approaches to evaluation, and learning gains. In addition, challenges and corresponding coping strategies are identified at three levels: individual, relational, and contextual.

Paper 2 aims to answer RQ 2. It develops an initial conceptual framework to describe different elements of learner agency for engineering students in an intercultural PBL setting. Adopting a narrative inquiry approach, ten elements are identified as contributive to learner agency which can be grouped into three dimensions (intrapersonal, behavioral, and environmental). The factors that participating students perceived as influencing the development of learner agency are also reported.

Paper 3 aims to answer RQ 3. A survey instrument was devised to explore which elements in intercultural PBL team settings that engineering students consider crucial for their learner agency development. By performing exploratory factor analysis, five factors emerged, and students were found to value internal sources, especially motivation and interest, as the most important factors supporting their learner agency development.

In summary, this PhD study broadens theoretical perspectives on learner agency and discusses the elements that might support its development in an intercultural PBL context. It is found that the learning process for engineering students has shifted from passively adapting to an intercultural PBL setting into proactively contribute to it through the process of building learner agency. Recommendations are provided for engineering students, educators, faculty staff, and institutions, and directions for future research into intercultural learning among engineering students are proposed.

DANSK RESUME

Betydningen af 'leaner agency' (herefter: læringsagens) er i stigende grad anerkendt inden for ingeniøruddannelser, da det har potentialet til at influere individers forestilling om professionel identitet og for deres beslutning om at fortsætte med deres uddannelse. Læringsagens er et komplekst og dynamisk system, hvori studerende spiller en aktiv og intentionel rolle i deres læringsprocesser. Det vedrører også deres evne til at tage ejerskab over deres egen læring, opstille målsætninger, regulere deres læringsaktiviteter samt at interagere med deres miljøer. Læringsagens er i overensstemmelse med principper inden for PBL (problem- eller projektbaseret læring), der er en konstruktivistisk læringstilgang med fokus på studentercentreret læring og aktivt engagement. I en PBL-kontekst arbejder fremtidens ingeniører i små grupper med komplekse og virkelighedsnære problemer, identificerer videnshuller og udforsker aktivt flere kilder til information og ressourcer. Dog kræver igangværende globale og sociale udfordringer, at fremtidige ingeniører ikke kun håndterer problemer inden for deres egne fagområder, men også at de udvikler interkulturelle kompetencer til at takle mere komplekse sociale problemer. Det er derfor nødvendigt at undersøge, hvordan ingeniørstuderende arbejder inden for en interkulturel PBL-rammesætning. Desuden er det stadig uklart, hvordan denne rammesætning bidrager til udviklingen af læringsagens blandt studerende. Denne undersøgelse stiler derfor mod at udforske udviklingen af læringsagens blandt ingeniørstuderende i en interkulturel PBL-rammesætning ved at besvare følgende forskningsspørgsmål:

> FS 1. Hvilke karakteristika, udfordringer og mestringsstrategier for interkulturelt samarbejde i studerendes grupper er blevet rapporteret i ingeniøruddannelsesforskning?
>
> FS 2. Hvordan opfatter ingeniørstuderende deres udvikling af læringsagens, og hvilke faktorer påvirker dens udvikling i et interkulturel PBL-miljø?
>
> FS 3. Hvilke elementer betragter ingeniørstuderende som vigtige i forhold til at arbejde i en interkulturel PBL-gruppe for at støtte deres udvikling af deres læringsagens?

For at besvare disse tre forskningsspørgsmål inkluderes tre artikler i denne ph.d.-afhandling. Artikel 1 anvender et systematisk litteraturstudie til at besvare FS 1. Analysen af 77 artikler identificerer flere karakteristika ved studerendes interkulturelle gruppearbejde, herunder gruppens struktur, samarbejdende lande, samarbejdsniveau, forberedelse til samarbejde, læringsmål, og tilgange til evaluering og læringsudbytte. Derudover identificeres udfordringer og tilsvarende strategier på tre niveauer: individuelt, relationelt og kontekstuelt.

Artikel 2 har til formål at besvare FS 2. I den artikel udvikles en teoretisk ramme til at beskrive kilderne for læringsagens for ingeniørstuderende i et interkulturel PBL-miljø. Der anvendes en narrativ undersøgelsesmetode, hvor ti aspekter bliver opdelt i tre dimensioner (intrapersonel, adfærdsmæssig og miljømæssig). Faktorerne som de deltagende studerende formoder påvirker udviklingen af læringsagens rapporteres også.

Artikel 3 har til formål at besvare FS 3. Et spørgeskemainstrument blev udviklet til at udforske hvilke elementer for ingeniørstuderende læringsagens i en interkulturel PBL-gruppesammensætning. Ved at udføre en eksplorativ faktoranalyse, blev fem faktorer identificeret, og det blev konstateret, at studerende fandt interne kilder, specielt motivation og interesse, værdifulde og de vigtigste faktorer, der understøtter deres udvikling af læringsagens.

Som opsummering udvider denne ph.d.-undersøgelse de teoretiske perspektiver på læringsagens, og diskuterer de elementer, der understøtter dets udvikling i en interkulturel PBL-kontekst. Jeg har opdaget, at læreprocessen for ingeniørstuderende er gået fra at tilpasse sig passivt til et interkulturelt PBL-miljø til aktivt at bidrage til den gennem opbygningen af læringsagens. Der gives anbefalinger til ingeniørstuderende, undervisere, videnskabeligt ansatte og institutioner, og der foreslås retninger for fremtidig forskning i kontekster med interkulturel læring blandt ingeniørstuderende som omdrejningspunkt.

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This PhD program started in July 2020 and finished in Nov 2023 at the Aalborg Center for PBL in Engineering Science and Sustainability under the auspices of UNESCO and Department of Planning & Institute for Advanced Study in PBL, Aalborg University. This wonderful journey has shaped me as a more independent researcher and has given me the passion and interest to do the research. I would like to express my deepest gratitude to the following individuals, who have contributed significantly to the completion of this PhD program.

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CHAPTER 1. INTRODUCTION

1.1. RESEARCH BACKGROUND

Ongoing global and social changes call for affirmation of the role of engineers as drivers of innovation, social and economic development (UNESCO, 2010). In engineering education, students are not only required to innovate and apply engineering and technology knowledge in practice, but also to develop the necessary competencies to address complex global challenges such as poverty, climate change, meeting basic human needs, developing infrastructure, securing a sustainable future and intercultural collaboration (UNESCO & ICEE, 2021). To do so, engineering graduates need to exercise learner agency and become more agentic, both in their own studies and throughout their professional lives. Learner agency reflects a sense of responsibility to participate in social activities and influence others and their circumstances for the better. Additionally, it shows the student's capacity to frame a guiding purpose and to identify the actions they need to take to achieve their learning goals (OECD, 2018).

In higher and engineering education, learner agency has become more important and it is built upon the interactions of several elements such as student-centeredness, decision-making, autonomy, self-organization, self-regulation, and collaboration (Du et al., 2022; Mercer, 2011, 2012). Learner agency describes learners' will and ability to set up goals, take actions, make independent choices, and reflect upon these choices (Campbell, 2012; Martin, 2004). It is about actively making their own decisions instead of reacting passively to those made by others (OECD, 2018). As one of the key agents in the learning process, student learners can actively engage with their learning contexts to build the knowledge, skills, and competencies necessary to address societal needs and the unpredictability of the future (Mason, 2008; Mercer, 2011). However, constrained agency among students may lead to dissatisfaction with learning, under-performance due to a lack of goals, and less of a sense of achievement and motivation (Francis et al., 2019; Harris et al., 2018). This, in turn, undermines students' self-confidence and well-being (OECD, 2018).

Prior literature has shown that certain pedagogical approaches, such as interdisciplinary learning, collaborative learning, contextual learning, experiential learning, self-directed learning and problem- and project-based learning (PBL), may support the development of learner agency among engineering students (Edström & Kolmos, 2014; Guerra et al., 2022; Savery, 2015). These approaches may help students become more proactive and agentic in their own learning processes (Soini et al., 2015). Among these pedagogical approaches, PBL empowers learners to take responsibility for their own learning process, integrate theory and practice, and apply their knowledge and skills to deal with complex, ill-defined and real-world problems (Edström & Kolmos, 2014; Savery, 2015). Students work in collaborative teams with

typically 3-4 members to co-construct meaning, identify what they need to learn together, find appropriate strategies for effective communication, and reflect on what they have learned and the effectiveness of the strategies they employed (Hmelo-Silver, 2004; Kolmos & de Graaff, 2014). Although a few previous studies have explored the enactment of learner agency in a PBL context, these studies were mainly conducted in a course-based PBL environment or among homogeneous student groups, and so shed little light on what elements in intercultural PBL contexts contribute to agency development involving students from diverse backgrounds (Du et al., 2022; Du & Naji, 2021).

Intercultural PBL combines students' intercultural learning with PBL, which benefits engineering students addressing complex technical issues by helping them consider diverse engineering solutions, evaluate the potential impact of their decisions in a global context, and cultivate a sense of global citizenship by connecting their learning to real-world social problems (Ota & Murakami-Suzuki, 2022). This is important so that engineering graduates are aware of the complexity of global interconnectedness and global challenges, and so that they can find strategies to accommodate change and innovation in future global workplaces (Downey et al., 2006; LaFave et al., 2015; Ota et al., 2019). In this sense, learner agency becomes even more important in intercultural PBL, because it promotes learners' belief in their ability to deal with complex socio-cultural challenges, increases their confidence in intercultural communication and innovation, helps them develop the autonomy needed for cultural exploration and understanding, and so on. However, previous studies on intercultural environments have tended to focus on students' adaptation to PBL or teamwork (Jiang et al., 2021a, 2021b). A different research perspective might perceive engineering students as proactive agents, rather than merely investigating how they conform to intercultural PBL or predetermined team practice.

This PhD thesis addresses these gaps in the literature. It was conducted in two phases. Phase 1 generated the first paper included in this study (Paper 1, a systematic review paper), which contributes to advancing current knowledge on the contexts, preparation strategies, learning gains and challenges encountered by engineering students in intercultural teamwork. The findings expand understanding of how to leverage diversity, drive technology and knowledge innovation, increase awareness of global issues, and foster the personal and professional growth of engineering students. Phase 2 contributed to two articles included in this thesis (Phase 2A, Papers 2, a qualitative paper and Phase 2B, Paper 3, a quantitative paper). This phase provided deeper insights into the topics of learner agency, intercultural learning, PBL and engineering education, outlined a conceptual framework for describing learner agency in an intercultural PBL setting, and analyzed empirical data gathered from multiple sources, such as interviews and surveys. Recommendations for engineering students, engineering faculty staff, educators, and engineering institutions were derived from these results.

1.2. RESEARCH OBJECTIVES AND QUESTIONS

The overall purpose of this study is to gain an understanding of how engineering students perceive their learner agency in an intercultural PBL setting. The specific objectives of the study are: (1) to provide an overview of how engineering students work in intercultural settings, specifically in intercultural teams; (2) to explore a small group of engineering students' reflections on how they perceive their learner agency development and what factors influence the development; (3) to explore a large sample of engineering students' perceptions of which identified elements in intercultural PBL settings crucial for learner agency development. Empirical investigations were therefore carried out to answer the following three research questions:

> RQ 1. What characteristics, challenges, and coping strategies of student intercultural team collaboration have been reported in engineering education research? (Paper 1)
>
> RQ 2. How do engineering students perceive their development of learner agency and what are the factors influencing its development in an intercultural PBL environment (Paper 2)
>
> RQ 3. What elements do engineering students consider important for supporting their development of learner agency in an intercultural PBL team? (Paper 3)

The papers will be further elaborated upon in the following sections. The objectives mentioned above and three research questions were finalized during the construction of the conceptual framework for this study, the formulation of the research design, the empirical data collection procedures, and the insights that arose during data analysis.

1.3. THESIS STRUCTURE

The thesis consists of two main parts: 1) the main body of the thesis, organized into five chapters, and 2) three appended papers. To provide a clear overview of the thesis, this section first outlines and briefly introduces the five chapters of the main thesis, then summarizes the three appended papers.

1.3.1. ORGANIZATION OF THE THESIS

Chapter 1 introduces the research background of the study and presents the research purpose and questions. The significance of the study and the thesis structure are

discussed. This chapter also includes a narrative of my own academic growth in which the positionality of my research is stated.

Chapter 2 begins by conceptualizing learner agency and discussing how this notion has been explored in empirical studies of higher and engineering education. An overview of PBL (problem- and project-based learning) is then presented based on its history, definition, principles, implementations, benefits for students' learning, and challenges. Next, the definition of intercultural learning and its present state in engineering education is discussed. Based on these concepts, a conceptual framework which takes account of multiple elements of learner agency is proposed for describing learner agency in intercultural PBL settings, and the research gap regarding this topic is also highlighted.

Chapter 3 presents the methodology of this study. It describes the research context, overall research design, data collection and analysis, validity and reliability procedures for the systematic literature review and exploratory sequential mixed method. Critical self-reflection on the use of these methods is also included in this chapter.

Chapter 4 discusses the findings of the three included papers in relation to the research questions. Using a systematic literature review approach, Paper 1 illustrates the general characteristics of intercultural student teamwork as reported in prior engineering education research. Based on a narrative inquiry method, Paper 2 explores a small group of engineering students' perceptions of how their learner agency is developed and what factors influence the development within an intercultural PBL context. From the findings of Paper 2, Paper 3 further investigates what supportive elements of learner agency identified in Paper 2 that engineering students consider more important, using a large sample size.

Chapter 5 begins by summarizing the three included papers. In addition, it presents the meta-reflections, main contributions, practical implications, and limitations of this study. Potential directions for future research are also discussed.

1.3.2. PAPERS INCLUDED

As previously mentioned, this thesis is comprised of three published papers (see the Appendices for the full texts of these papers). They are referred to as Papers 1-3. These papers are summarized in later sections, and coherence between the papers, their research designs, research questions and purposes are discussed.

Paper 1: Jiang, D., Dahl, B., & Du, X. (2023). A Systematic Review of Engineering Students in Intercultural Teamwork: Characteristics, Challenges, and Coping Strategies. *Education Sciences*, *13*(6), [540].

To link to this article online: https://doi.org/10.3390/educsci13060540

This is an open access paper. It systematically reviews prior studies to investigate characteristics, challenges, and coping strategies involved in intercultural teamwork between students in engineering education. Using the search-screen-appraise method, 77 journal articles were identified as relevant. Several characteristics of intercultural teams were reported, including team formats, cooperating countries, different levels of collaboration, preparation and evaluation strategies, learning goals, and learning gains. Several challenges and corresponding coping strategies are also reported at three levels – individual, interactional, and contextual. Based on the results, several recommendations for future studies and engineering educators are made, such as recognizing the importance of understanding culture, intercultural team preparation, the opinions of academic staff on evaluation methods, actual engagement in intercultural teamwork, coping strategies for psychological challenges, challenges relating to prior background and experience, and so on. Thus, this paper answers research question 1 in this PhD thesis.

Paper 2: Jiang, D., Dahl, B., & Du, X. (2022). A narrative inquiry into developing learner agency of engineering students in an intercultural PBL environment. *European Journal of Engineering Education*, *47*(6), 1103-1121.

To link to this article online: https://doi.org/10.1080/03043797.2022.2119371

The Editor-in-Chief of the European Journal of Engineering Education, Dr. Kristina Edström, has kindly granted permission for the use of the full text of this paper in this thesis. This paper focuses on how do engineering students perceive their learner agency development, and the factors they perceive as influencing to their development in an intercultural PBL environment. A three-dimensional conceptual framework taking account of multiple elements – intrapersonal, behavioral, and environmental – was proposed. Data was collected from eleven engineering students using a narrative inquiry approach. The analysis results indicate that these students perceived that ten elements supported them develop their learner agency, grouped under the three aforementioned dimensions. The factors that engineering students perceived to influence their agency building were also reported. This study has practical implications for engineering students, staffs, educators, and higher educational institutions and can help to facilitate and support the development of learner agency among engineering students from diverse backgrounds. This paper answers research question 2 in this PhD thesis.

Paper 3: Jiang, D., Dahl, B., Chen, J., & Du, X. (2023). Engineering Students' Perception of Learner Agency Development in an Intercultural PBL (Problem- and Project-based) Team Setting. *IEEE Transactions on Education*. 1-11. (E-pub ahead of print).

To link to this article online: https://doi.org/10.1109/TE.2023.3273177

The Editor-in-Chief of the IEEE Transactions on Education, Prof. John Mitchell, has kindly granted permission for the use of the full text of this paper in this thesis. This paper explores what elements of learner agency in an intercultural PBL setting that engineering students consider important to the learner agency development, using a large sample size. Three interrelated dimensions, namely intrapersonal, behavioral, and environmental dimensions, were used to frame learner agency. A new survey instrument was constructed based on this framework, and 310 undergraduate and graduate engineering students responded to the instrument. This study analyzed content validity (through expert review), construct validity for exploratory factor analysis, and reliability (using Cronbach's alpha) to explore how many factors link the items. As a result, five factors were identified, along with several demographic variables that related to agency development among engineering students. This study not only aspires to generate a deeper understanding of the learning experience of engineering students in intercultural PBL teams, but also to provide several preliminary recommendations for engineering educators and institutions, including a recommendation to focus on certain groups when organizing intercultural team activities. It also calls for further studies comparing different groups using different sources of data, such as interviews, observations, or different kinds of quantitative statistical analysis. This paper answers research question 3 of this PhD thesis.

1.4. POSITIONALITY STATEMENT

My academic journey in Denmark began in 2018 when I arrived at Aalborg University (AAU), Denmark in 2018 to teach Chinese language and culture and first encountered a Danish PBL setting. My colleagues had explored how tasks and task-based PBL can used in Chinese teaching and learning for several years. Guided and inspired by them, I followed some PBL principles, explored multiple cultural activities, and used a constructive approach to design language tasks in my class. I slowly shifted my mindset from focusing on transmitting knowledge to helping my students develop meaningful learning in their situated contexts. This helped me realize that culture is not merely one's nationality, but also the dynamically interactive and constructive process one participates in with others and their environment. My two-year teaching and learning experience motivated my own research interest on intercultural PBL and empowered me to develop an intercultural mindset and sensitivity by connecting with

students from different countries and negotiating their learning needs while recognizing different perspectives based on a shared reality.

The first year of my PhD began with a pilot study interviewing Chinese engineering students about their adaptation to a Danish PBL context. My ethnic background, previous schooling experience in China, prior teaching experience and role as an international student helped me to understand the encounters of these international students with intercultural issues in Denmark in general, and in particular with the PBL environment in Aalborg University. Chinese students, including myself, experience hugely different social hierarchies, communication styles, cultural beliefs, and educational values in Denmark. However, the similarities between my background and the participating students' had the potential to blind me to the particularities of the "strange" situation of their learning experiences. By listening to their stories of academic growth in a PBL environment and being enriched with literature on constructive approaches to understanding culture and learning, my understanding has been transformed: having initially seen intercultural PBL as an adaptation, I now see it as an opportunity to proactively develop and construct learning during the PhD process.

This stimulated my curiosity about learner agency among a whole range of both Danish and international students. It also influenced my decision to use exploratory mixed methods by first using a narrative inquiry approach to listen to the stories of small groups of engineering students, and subsequently investigating a larger sample size at AAU through the design of a new survey instrument. However, I do not have an engineering background, nor have I been trained in any engineering and technical programs. This could limit my understanding of certain concepts in the engineering field and had the potential to lead to misinterpretations of engineering students' accounts of their experience. To address this, in the first and second years of my PhD I conducted a systematic literature review which helped me understand the characteristics and challenges of engineering students' intercultural teamwork from the perspectives of engineering educators and researchers around the globe. Both my review and interviews with Chinese students helped me relate to participants at the later stages of the research. The similarities between my experience and some of the engineering students' experiences influenced my interpretations and analysis of both qualitative and quantitative data and helped me construct a holistic picture of different elements of learner agency that related to engineering students' learner agency development.

CHAPTER 2. THEORIES AND LITERATURE REVIEW

2.1. LEARNER AGENCY

This section will begin by defining learner agency, then discuss empirical studies relevant to this concept in higher and engineering education.

2.1.1. CONCEPTUALIZING LEARNER AGENCY

Before defining learner agency, it is necessary to first discuss the concept of agency itself. Originating from the social sciences, this concept has become increasingly popular in the fields of education, psychology, anthropology, and in studies of working life and gender research (Eteläpelto et al., 2013). In educational settings specifically, "agency" describes one's capacity "*to make free or independent choices, to engage in autonomous actions, and to exercise judgement in the interest of others and oneself*" (Campbell, 2012, p.183). The concept of agency has been explored in various ways; the most relevant to this study are the socio-cognitive perspective and the subject-centered social-cultural approach.

From a socio-cognitive perspective, agency is the psychological process by which an individual develops or gains knowledge (Bandura, 2006), and encompasses students' inclination towards cognitive development or learning. It serves as a mediating factor among multiple elements linking thoughts and actions, including self-management, self-efficacy, self-regulation, self-reflection, and metacognitive control over learning (Bandura, 2006). Here, self-management is understood as a person's capacity to generate goals for their own engagement through cognitive representations of desired outcomes that align with their strengths and preferences (Bandura, 2006, 2008). Self-efficacy refers to a person's beliefs about their ability to take the action necessary to reach their expected goals (Schunk & Zimmerman, 2007). Self-regulation concerns a person's ability to control their behaviors through the practice of self-efficacy, goal orientation and planning, and precedes attempts to learn through attribution, self-monitoring, and self-evaluation (Zimmerman, 1990, 2013). Notably, agency is enacted not only through individual autonomy, but also through a proxy-based and collective approach where individuals work together and influence others to combine their knowledge, skills, and resources in the pursuit of shared learning goals, and may use persistence and decision-making to act on tasks despite challenges and difficulties (Bandura, 2018).

The subject-centered sociocultural approach is another widely recognized perspective. This approach views agency as the development of cognition and the performance of

agentic actions within certain social, historical, or cultural contexts that are constantly changing (Eteläpelto et al. 2013). It highlights a process in which subjects/individuals learn about themselves and proactively create their own subjectivity. It further manifests subjects' centeredness when constructing and negotiating their agency in educational and working life (Eteläpelto, 2008). In this sense, agency is dynamic in terms of the relationship between individuals' agentic behaviors and their social context, in which they engage in social practices and social construction of knowledge (Billett, 2008; Jääskelä et al., 2021; Sawyer, 2012). In addition to social and cultural structures, an individuals' subjective perceptions, meanings, and purposes for action are also crucial influences on their agency in a social-cultural learning environment (Jääskelä et al., 2020). This approach suggests that agency occurs during the autonomous learning engagement of individuals in specific sociocultural contexts and that contextual factors may facilitate or constrain their capacity to act (Mercer, 2012).

To better understand learner agency, it is also necessary to define what learning is. Complexity theory recognizes learning as a complex, nonlinear process in which individuals, the social group, and the society more broadly interact, emerge and co-evolve (Mason, 2008; Morrison, 2008). This theory concerns elements such as change, evolution, adaptation, and development in educational settings. It not only re-examines reductionist and mechanistic thinking to provide a more holistic view, but also highlights the need for self-organized, dynamic educational systems to accommodate societal changes (Mercer, 2011, 2012; Morrison, 2008). Furthermore, the role of teachers shifts from authorized knowledge transmitters to co-constructors of meaning and new knowledge by enabling learners to work together on complex and real-world problems. As a result, student learners make active choices and exercise their autonomy, responsibility, ownership, self-direction, and reflection to respond to uncertainty and change (Mason, 2008; Mercer, 2012; Morrison, 2008).

Guided by a socio-cognitive perspective and a subject-centered social cultural approach to the comprehension of agency, and an understanding of learning gained through the lens of complexity theory, learner agency can thus be defined as a dynamic, complex system with three interrelated aspects: 1) learners' sense of agency; 2) learners' agentic behaviors; and 3) learners' interaction with their environment (Du et al., 2022). Figure 2-1 visualizes these three aspects and the relations between them. This figure helps form a deeper and clearer understanding of the concept of learner agency and support the development of a conceptual framework for discussing learner agency in an intercultural PBL context at a later stage.

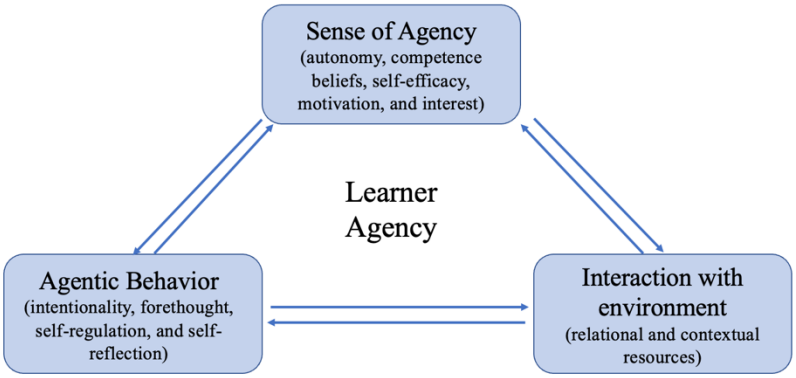

Figure 2-1 Model of the dimensions, relationships, and resources of learner agency (Derived from (Bandura, 2006, 2008; Du et al., 2022; Jääskelä et al., 2017, 2021; Mercer, 2011, 2012)

The first aspect, learners' sense of agency, concerns the extent to which learners feel agentic in both general and specific contexts (Mercer, 2012). This is understood as subjective perceptions of their agency in given contexts (Archer, 2003). From prior studies, this is reflected by personal sources such as autonomy, beliefs, efficacy, motivation, and interests (Jääskelä et al., 2017, 2021; Mercer, 2011, 2012). First, Bandura noted that one's self-efficacy influences one's actions through cognitive, motivational, and affective intervening processes (Bandura, 2006). Strong self-efficacy will promote one's well-being and motivation (Jääskelä et al., 2017). A person's beliefs include their self-evaluation of their development of knowledge, skills, and strategies, and the impact of their perceptions of how their goals can be achieved through strategic actions on their actual learning behaviours (Hatlevik et al., 2018; Jääskelä et al., 2017). Beliefs about self-concept, self-confidence, and identity are particularly relevant in this context (Mercer, 2011; Ruohotie-Lyhty & Moate, 2016). Conversely, a lack of belief or the presence of negative beliefs may have a negative effect on a person's engagement. Prior studies have also pointed out the relation between motivation and interest in terms of agency, claiming that interest influences learners' decisions to act in certain ways or to choose passivity (Bandura, 2006; Mercer, 2012; Ryan & Deci, 2009).

The second aspect, learners' agentic behaviors, refers to how learners choose to exercise their agency through participation and action, which may be deliberate or unconscious, active or passive (Mercer, 2012). In this aspect, Bandura (2006) identified four core links between thoughts and agentic actions: intentionality, forethought, self-regulation, and self-reflection. Intentionality means an awareness and will to act which is actualized through goal setting and planning, while forethought involves the ability to anticipate desired outcomes. Self-regulation is "an

active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate and control their cognition, motivation, and behavior" (Pintrich, 2000, p.453). Learners, being more than mere agents of actions, also self-reflect on their personal efficacy, the soundness of their thoughts and actions, and the meanings of their pursuits, and make adjustments when necessary (Bandura, 2008, 2018).

Given that individuals possess the ability to execute control over their personal development and life circumstances, several contextual attributes have been recognized as pivotal for the encouragement of learner agency. In the higher education literature, the last aspect, learners' interactions with their environments, includes both relational sources and contextual features. Relational sources include reciprocal relationships between teachers and students (Jääskelä et al., 2017) and among students (Lipponen & Kumpulainen, 2011), mutual support from peers (Edwards, 2011), and trust building in a safe learning atmosphere (Eteläpelto & Lahti, 2008). The team setting can be also seen an important element in this context. This includes effective communication, constructive mutual feedback, and efficient conflict resolution (Hökkä et al., 2017). Contextual features are often related to sociocultural and environmental aspects, including external support from teachers, the efficient utilization of facilities, and interactions with communities and institutions, and the regulations and policies defined by the surrounding institutional environment (Du & Naji, 2021; Jääskelä et al., 2017, 2021).

2.1.2. HOW LEARNER AGENCY HAS BEEN STUDIED

This section discusses how the learner agency of students in higher and engineering education has been studied from diverse perspectives and in different ways.

A recent literature review on the learner agency of students in higher education provides a broad overview of the relationship between agency and student learning (Stenalt & Lassesen, 2022). This review divides student learner agency into several categories, with epistemic agency, relational agency, and agency in connection to globalization and internationalization being the most pertinent to this thesis (Stenalt & Lassesen, 2022). As illustrated by (Damşa et al., 2010), students' epistemic agency is essential to support the co-creation of shared knowledge in a collaborative context. This agency has two major dimensions: the epistemic dimension and the regulative dimension. The former is related to the process of knowledge creation, which requires shared understandings, the generation and structuring of new ideas based on shared goals, and persistence in planning actions. The latter dimension is related to regulative and relational process, which includes setting up goals, planning, monitoring joint efforts, and negotiating with others (Damşa et al., 2010). Relational agency concerns one's ability to work with others to find meaningful responses to complex problems (Edwards, 2011). It not only focuses on personal autonomy, but also encompasses interdependence, reciprocal interactions, and joint actions with others (Stenalt, 2021).

In this sense, relational agency is embedded in manifold social and dynamic relations. With regard to agency in relation with globalization and internationalization, (Kudo et al., 2020) indicated that student-initiated activities had a greater influence than university-engineered activities on the promotion of intercultural relationship development. Students are able to exercise and cultivate their agency to initiate meaningful intercultural interactions in environments which are created and owned by them (Kudo et al., 2020). However, since these types of agency only address one or two aspects of learner agency, it is vital to generate a more comprehensive understanding of this topic. Additionally, none of these other forms of agency have yet been examined within a PBL setting; this research gap drives me to explore learner agency in such a context.

In an empirical higher education study, (Jääskelä et al., 2017) developed the Agency of University Students (AUS) scale to measure and examine the enactment of learner agency by students. The analysis revealed that agency development is supported or constrained by personal resources (e.g., self-efficacy beliefs, intrinsic motivation, competence beliefs, participation activity, etc.), relational resources (e.g., reciprocal relations between teachers and students, mutual support from peers, and learning environment with trust and safety), and contextual resources (e.g., external support from instructors, the efficient use of facilities, and interactions with courses, communities or institutions) (Jääskelä et al., 2017, 2021). Although this scale requires further investigation in the context of engineering education, it helps me understand the sources that are relevant to learner agency and identify the key sources.

The concept of learner agency has begun to receive more attention in engineering education research in recent years. However, most studies have focused on sub-themes of learner agency. For instance, (Godwin et al., 2016) analyzed the relationship between students' agentic choices in engineering studies and their development of engineering identities. (Secules et al., 2018) tracked the development of personal agency by a female engineering student over time, highlighting the importance of self-regulation. To examine the career choices made by engineering students, (Godwin & Kirn, 2020) linked motivation and metacognitive beliefs to engineering identity. However, learner agency was neither the primary focus of these studies, nor was it discussed in much detail.

Recent literature has revealed that engineering students value different aspects of learner agency in different PBL scenarios. For instance, as Du et al. (2022) pointed out in relation to a PBL setting in Qatar, although civil engineering students perceive the aspects of the PBL process that support learner agency, they still rely largely on direct guidance and support from course instructors and project supervisors. Associating learner agency with sustainability, engineering students prioritized personal values of learner agency such as motivation, efficacy beliefs and awareness in a Danish systemic PBL context by Guerra et al. (2022). However, behavioral dimensions of sustainability are less often addressed by students and they exhibit

passivity when interacting with the contexts they are situated in Guerra et al. (2022). Until now, little has been known about which aspects of learner agency are valued by engineering students in intercultural PBL settings. Hence, this PhD research aims to develop an in-depth understanding of this and address the associated problems.

In conclusion, although earlier engineering education studies have examined the relational, contextual, and epistemic aspects of learner agency, agency in connection with internationalization or interculturality should be explored in similar depth. Furthermore, although learner agency has been studied in the context of PBL and sustainability, the ways in which students develop agency within wider intercultural PBL settings also demand further attention. To delve into intercultural PBL, the next section will provide an overview of PBL and how it supports student learning in higher and engineering education.

2.2. PROBLEM- AND PROJECT-BASED LEARNING (PBL)

This section presents the history, definition, and principles of PBL, and the benefits and challenges its implementation can have for students.

2.2.1. A BRIEF OVERVIEW AND DEFINITION OF PBL

In response to the societal need for new knowledge and skills in the labor market, and for greater democracy and student influence, many universities invented new teaching and learning models during the late 1960s and early 1970s (Kolmos & de Graaff, 2014). Problem- and project-based learning (PBL) emerged from this time. In 1969, a new medical curriculum based on PBL was pioneered at the medical school of McMaster University in Canada (Barrows, 1996). Aiming to train general practitioners in health and medicine, PBL was seen as a student-centered educational approach whereby students took responsibility for their learning, dealt with real-life and unresolved ill-structured problems, and identified their own learning and content needs (Barrows, 1996). In PBL, students were provided with opportunities to work intensively and effectively in small teams. Teachers acted as facilitators, without giving students direct information or guidance (Barrows, 2002).

Since then, PBL has attracted broad international attention. Aside from the work at McMaster University, in 1970s, pioneer work was also being carried out at Aalborg University (Denmark), Roskilde University (Denmark), Newcastle University (Australia), Michigan State University (USA), and Maastricht University (the Netherlands) (Hillen et al., 2010). PBL began to be applied in other subject areas such as engineering, science, social science, and the humanities (Edström & Kolmos, 2014; Kolmos & de Graaff, 2014). As PBL became well-established and widely

acknowledged, it was also extended to educational practices and was discussed at various educational levels.

During the 1970s, PBL research in educational settings can be described as descriptive and conceptual. These investigations contributed to the conceptualization, understanding, and creation of an analytical framework for new and innovative practices (e.g., Neufeld & Barrows, 1974). From the 1980s to the 2000s, a large number of empirical studies were conducted to evaluate the effects of PBL, explore its basic learning principles and characteristics, discuss students' learning processes and experiences, focus on new types of curriculum structure and content, and so on (e.g., Boud, 1985; Dochy et al., 2003; Gijbels et al., 2005; Wilkerson, 1996). Over the last decade, PBL has been discussed in a more systemic way and the cultural dimension has come to be regarded as more important. Based on the current assumptions of social constructivism, knowledge is constructed by learners' interactions with the wider environment, and problems should be analyzed in terms of their broader socio-cultural context. It is also emphasized that meaning and thinking should be rooted in the culture and community in which learners exist (Marra et al., 2014). In this sense, PBL is viewed as a flexible, adaptable, and culturally relevant learning approach (Savin-Baden, 2014).

Within the field of engineering education, the central learning principles in both problem- and project-based learning concern three dimensions: the problem, the content and the team (Du et al., 2009; Graaff & Kolmos, 2007). In the problem dimension, learning is structured around problems and conducted in projects. Problems, which are the prerequisites for learning processes, are contextualized and rooted in learners' experience. Within the projects, tasks involve complex analyses and problem-solving strategies (Du et al., 2009). The content dimension consists of interdisciplinary learning, the relationship between theory and practice, and exemplary practice. Interdisciplinary learning involves solutions which transcend traditional subject-based boundaries (Kolmos & de Graaff, 2014). Although the problems should mostly be rooted in practice, theory is required to analyze these problems (Du et al., 2009). Moreover, the problems should be exemplary of the overall learning objectives (Kolmos & de Graaff, 2014). Finally, in the team dimension, team-based learning emphasizes students learning from each other, sharing knowledge, and self-regulating their collaborative learning processes (Edström & Kolmos, 2014). Participant-directed learning is also part of team-based learning, involving students taking collective ownership of the learning process and especially the formulation of problems (Du et al., 2009).

Based on prior studies and learning principles, in this study PBL is conceptualized as a self-directed, student-centered approach whereby learners take ownership of the learning process, stimulate their curiosity by identifying complex and contextual problems, acquire cognitive strategies and domain knowledge, and develop generic skills (Kolmos et al., 2021). In addition, it is a constructivist pedagogy whereby

learners not only individually construct meanings about their learning through active engagement and self-reflection (Kolmos & de Graaff, 2014), but also co-create knowledge in teams, solve complex problems together, and develop strategies through sense-making and effective communication (Savery, 2015). They also interact with a broader socio-cultural context to meet various different societal challenges and changes (Kolmos et al., 2021; Savin-Baden, 2014).

2.2.2. HOW PBL SUPPORTS STUDENT LEARNING IN ENGINEERING EDUCATION

This section discusses PBL implementation, how PBL benefits student learning in engineering education, and challenges that engineering students encountered when working in a PBL setting.

A recent literature review examined 108 empirical studies and identified a variety of PBL implementations at the course, cross-course, curriculum, and project levels (Chen et al., 2021). PBL at the course level is reported to be practiced with higher frequency, in a one-semester single course. However, students usually come from a single discipline and focus on scenarios and problems narrowly related to that discipline. Furthermore, course-level project problems are mostly assigned by teachers, with few opportunities for the students to identify problems themselves (Dong & Guo, 2014). PBL at the cross-course and curriculum level goes beyond a single course and is implemented in academic programs within a higher education institution. These implementations are more project-based and provide engineering students with opportunities to work in interdisciplinary teams or with clients from industry (Tan & Shen, 2018; Terrón-López et al., 2015). At the project level, students participate in both institutional and cross-institutional projects within one or more countries (Chen et al., 2021). In international projects especially, students are able to experience cultural diversity, and develop their international horizons (Ota et al., 2019). However, discussions about how PBL is implemented in intercultural settings are still limited in the studies included in the review; more focus is thus needed to explore both students' and teachers' experiences in intercultural PBL settings.

Recent studies have pointed out that PBL benefits student learning in various different ways. For instance, Zhou et al. (2011) indicated that PBL environments foster team creativity and stimulate student motivation. The use of PBL has also been found to increase student engagement during lectures and throughout the entire semester (Abu-aisheh et al., 2016), help students transition from passive note-takers to active and lifelong learners (Ahern, 2010), promote a better and deeper understanding of learning content, tackle projects using a holistic approach (Pinho-Lopes, 2018), and prepare to find solutions for social issues and methods of technology localization (Ota et al., 2019). Although a recent review has pointed out that engineering students perceive an increase in their teamwork and communication skills, competences such as critical thinking, metacognition, self-directed learning, self-efficacy, and self-regulation have

received less attention (Boelt et al., 2022). A literature gap in previous PBL research thus emerges: there is a need for a comprehensive understanding of learner-centeredness, self-regulation, collaboration, and autonomy in PBL within the engineering education field (Du et al., 2022). In this sense, the notion of learner agency becomes crucial for finding links between learners' personal values, actions and situated environments.

Despite the benefits of PBL for engineering students, several challenges experienced by students in PBL implementation have been identified, including limited prior experience, interpersonal obstacles, and a lack of teamwork, self-learning, and project management skills. Students are also presented with challenges relating to institutions such as lack of support from departments, and to differences in cultural backgrounds, such as different languages, nationalities, and cultural customs (Chen et al., 2021). For PBL beginners, the transition from traditional lecture-based approaches to innovative PBL approaches may cause some problems. These problems are even more significant when working in culturally different or intercultural PBL environments (Jiang et al., 2021a). These challenges increase the urgency of the need to promote learner agency, which emphasize students' active role in transitioning to and contributing to such an environment, rather than passively receiving information and knowledge.

To sum up, although prior research provides abundant theoretical and empirical evidence regarding the principles, implementation, benefits, and challenges of PBL, less focus has been put on engineering students' learning in intercultural PBL settings, and on the role of learner agency in such an environment. In light of this, it is also necessary to provide an overview of intercultural learning within engineering education before outlining our conceptual framework.

2.3. INTERCULTURAL LEARNING

2.3.1. DEFINING INTERCULTURAL LEARNING

To investigate intercultural learning, this section begins with a discussion of contrasting views on how culture can be conceptualized. Following Handford et al. (2019), culture can be framed as both a given and a construct. The culture-as-given approach describes culture as predetermined groups based on nationality, emphasizing the distinctions between national cultures (Handford et al., 2019). It considers culture as something inherent, which people belong to or are born into. This approach has been influenced by Hofstede and Minkov (2010), who defined and analyzed dimensions of national cultures in terms of power distance, uncertainty avoidance, individualism-collectivism, masculinity-femininity, and short-term and long-term orientation. However, this view is seen as overly simplistic and restricts the

concept of culture to mere nationality. Furthermore, it has been criticized for its predominantly static view on culture, which implies that one must hold certain beliefs and values, or behave in certain ways, that are defined by one's culture. It may reinforce stereotypes and result in narrative of inability, which can hinder an individual's maximization of their personal strengths (Holliday et al., 2017).

The culture-as-construct approach considers culture through the lens of constructivism and complexity theory. Dervin (2011) views culture as something liquid; according to this view, cultures are not fixed and homogeneous entities, but social constructs generated by individuals. This liquidity emphasizes that individuals participate in constant negotiation and development, from small social groupings and communities to much larger international entities and societies (Holliday, 1999). In this sense, culture is understood as a complex, dynamic, and ever-changing process that transcends national frontiers and has blurred boundaries (Dervin, 2011). Subjectivity, knowledge, and society all interact and impact one another to jointly create meanings and establish appropriate behaviors (Dervin, 2010; Handford et al., 2019). The culture-as-construct approach thus defines intercultural learning as an interactive and dynamic process, wherein a group of individuals dynamically interact with other groups or wider society to cultivate intercultural awareness, mindset, communication, and competence (Dervin, 2010, 2011; Handford et al., 2019; Holliday et al., 2017). As a result, intercultural learners have the opportunity to broaden their cultural perspectives in order to form an appreciation for diversity and develop their understanding of the global community.

Working in an intercultural learning environment involves a process of changing one's knowledge and attitudes about culture, and presents interactions and reflections that result in new frames of reference, communication styles, and behaviors (Burdett, 2013). Several studies have defined and categorized intercultural learning across three dimensions: cognitive, affective, and behavioral (Deardorff, 2006; Garson, 2013; Hunter & Hunter, 2004). The subthemes of these dimensions and the relations between them are presented in Table 2-1. These dimensions and sub-themes guided me to consider key intercultural components while constructing the conceptual framework.

The cognitive dimension includes both awareness and knowledge on culture (Deardorff, 2006). Awareness includes both cultural awareness. Cultural awareness refers to recognition of, and sensitivity to, cultural similarities or differences, serving as a prerequisite for intercultural learning (Bennett, 2009). It goes beyond views of cultures as fixed entities and recognizes cultural references and modes of communication as being both related to specific cultures and an emergent and dynamic means of sharing experience (Baker, 2011). In this sense, to manage more extensive differences, learners may be required to gather knowledge about not only specific cultures, but also culture in general (Bennett, 2015). According to Deardorff (2006, 2009), this knowledge encompasses the contexts, roles and impacts of different

cultures and others' world views to support effective interaction in a variety of cultural contexts.

Dimension	Definition	Subthemes
Cognitive	Awareness and knowledge of culture	- awareness (incl. sensitivity, understanding, recognition) - knowledge
Affective	Learners' attitudes and emotions toward interculturality	- openness - curiosity - discovery - respect - negative emotions (e.g. confusion, anger, loneliness, etc.) - positive emotions (sense of belonging and security, satisfaction, pleasure, etc.)
Behavioral	Learners' actions to find appropriate intercultural behaviors	- listening - observing - communicating - evaluating - critically reflecting - relating

Table 2-1 Three dimensions of intercultural learning

The affective dimension focuses primarily on learners' attitudes and emotions toward other cultures and cross-cultural interactions (Garson, 2013; Hunter & Hunter, 2004). An effective intercultural learner maintains an attitude of openness, curiosity, discovery, and respect. Openness refers to a non-judgmental reaction to intercultural learning and individuals from other cultures. Respect means valuing all cultures and cultural diversity. One's curiosity and discovery indicate to what extent one can tolerate uncertainty (Deardorff, 2006, 2009). In addition, emotion also plays a vital role in intercultural learning. Recognizing and managing emotions may contribute to the construction of meaning when facing changes, facilitate the intercultural learning process, and empower individuals to take action (Jokikokko, 2016). During these processes, learners may experience either negative (e.g. confusion, anger, feelings of otherness and discomfort, loneliness, etc.) or positive (e.g. feelings of belonging and acceptance, sense of safety, satisfaction, pleasure, etc.) emotions (Jokikokko, 2016, 2016; Porter & Samovar, 1996).

The behavioral dimension addresses learners' actions in adapting to different communication styles and finding appropriate and effective behaviors in an unfamiliar cultural context (Bennett, 2009; Deardorff, 2006, 2009). In an intercultural environment, the development of intercultural skills enables learners to achieve more appropriate intercultural behaviors. These include the skills they need to listen to and

observe others, to effectively communicate in intercultural situations, to analyze, to relate their acquired intercultural knowledge to their situation, to interpret and analyze situated intercultural scenarios, to assess and evaluate intercultural performance using patience and perseverance, to adjust to new cultural environments, and so on (Deardorff, 2006; Hunter & Hunter, 2004).

2.3.2. INTERCULTURAL LEARNING IN ENGINEERING EDUCATION

Due to an increasing focus on internationalization and cultural diversity in engineering education research, several empirical studies have reported findings on the topics such as assessment of intercultural learning through quantitative instruments, intercultural challenges, and the development of intercultural competence.

Most intercultural learning instruments implemented in engineering education concentrate on the cognitive and affective dimensions of intercultural learning. These include the Intercultural Development Inventory (IDI) which assesses intercultural sensitivity (Thompson & Jesiek, 2010), the Universal-Diverse Orientation scale of intercultural awareness and appreciation (Jesiek et al., 2012), and the Cross-cultural Adaptability Inventory (CCAI) and Global Awareness Profile (GAP) tests of intercultural effectiveness and awareness (Del Vitto, 2008). However, since these instruments only assess one or two aspects of intercultural learning, additional investigation is required to find ways of measuring students' intercultural learning in a more comprehensive manner. Moreover, none of the aforementioned instruments focus on learner agency or student learning in intercultural teams. Therefore, it is necessary to delve into student learning in intercultural teams by assessing a larger population and exploring their perceptions of agency building.

Some prior studies have reported the challenges that engineering students generally encounter in intercultural environments. These include language barriers and ineffective communication (González et al., 2008), a lack of interpersonal relations (Bergman et al., 2022), and different ways of working and thinking (Bani-Hani et al., 2018). However, an overview of the challenges that engineering students encounter in intercultural teams and how they deal with these issues has not yet to be produced. The intercultural competences developed by engineering students have also been discussed in the literature. These include language skills, team management, behavioral flexibility, interaction relaxation (LaFave et al., 2015), and effective communication (Handford et al., 2019). It is also worth discussing methods of evaluating these learning gains and how students preparing for their intercultural learning.

In PBL, team-based learning is one of the most important ways for engineering students to co-construct knowledge and develop team-related competences. Previous studies have shown that engineering students often work either in intercultural teams within the same institutions (e.g., Popov et al., 2022), or globally distributed virtual

teams (e.g., Ota et al., 2019). The former might be comprised of both local and international students with diverse cultural backgrounds. Team members often come from different engineering disciplines in the same university. The latter has become more common in recent years due to improvements in technology and increasing demand for remote collaboration (Anderson & Ramalingam, 2021). Student groups from different parts of the world may collaborate on the same tasks or projects online, communicating by means of various virtual tools such as email and video- or tele-conferencing (Gładysz & Jarzębowska, 2018; McCullough et al., 2019).

It has been pointed out that intercultural team collaboration increases engineering students' awareness of cultural differences (Jesiek et al., 2012), and helps them gain knowledge and understanding of engineering problems in global contexts (Downey et al., 2006). Affectively, their prejudices and stereotypes about other cultures are reduced (Frambach et al., 2014), and they become more open, respectful, and sensitive (LaFave et al., 2015; Ota et al., 2019). Behaviorally, they develop new ideas, learning practices and interaction skills (Spencer-Oatey & Dauber, 2019), and increase their flexibility when carrying out complex tasks (LaFave et al., 2015). In addition to learning gains, several intercultural team challenges have also been illustrated in the literature. Interactional challenges such as differences in communication styles and ineffective communication (Montgomery, 2009; Soibelman et al., 2011), team-building challenges such as passive engagement from group members (Bergman et al., 2022; Popov et al., 2022), and language barriers (e.g., Anderson & Ramalingam, 2021), are the challenges most frequently reported in prior studies.

A previous review on intercultural engineering education mainly focused on ways of conceptualizing culture (Handford et al., 2019). Although a growing number of studies have presented findings relating to intercultural team settings, there remains a lack of a comprehensive overview of their characteristics and challenges. Furthermore, coping strategies for dealing with these intercultural challenges have not been clearly summarized. These research gaps motivated the systematic investigation of intercultural teams within engineering education presented in Paper 1. Furthermore, it was also necessary to discuss how learner agency is enacted in both PBL and intercultural settings; this is the subject of Papers 2 and 3.

Inspired by the concept and characteristics of PBL, a model of learner agency, and the three dimensions of intercultural learning, a conceptual framework was thus proposed

to describe learner agency in an intercultural PBL setting. It will be elaborated in the next section.

2.4. A CONCEPTUAL FRAMEWORK OF LEARNER AGENCY IN INTERCULTURAL PBL SETTINGS

Bringing together the concept of learner agency and its interrelated aspects, the definition of PBL and its learning principles, and the three dimensions of intercultural learning helps identify and establish linkages between these theories. On this basis, a conceptual framework was designed to describe the elements of learner agency in intercultural PBL settings. This framework, presented in Figure 2-2, consists of three dimensions: intrapersonal, behavioral, and environmental supported by multiple elements. The elements of a sense of agency discussed in Section 2.1.1 and the cognitive and affective subthemes of intercultural learning discussed in Section 2.3.1 fall within the intrapersonal dimension of the framework. The behavioral dimension involves the agentic behaviors (in Section 2.1.1) and intercultural behaviors (in Section 2.3.1). The environmental dimension incorporates interactions between learners, the team settings they are situated in, and their broader socio-cultural environment. Based on a review of prior literature, a conceptual framework for describing learner agency and details of elements of learner agency gathered from prior literature in an intercultural PBL environment are shown in Figure 2-2 and Table 2-2 respectively. They are followed by more elaborations on these elements.

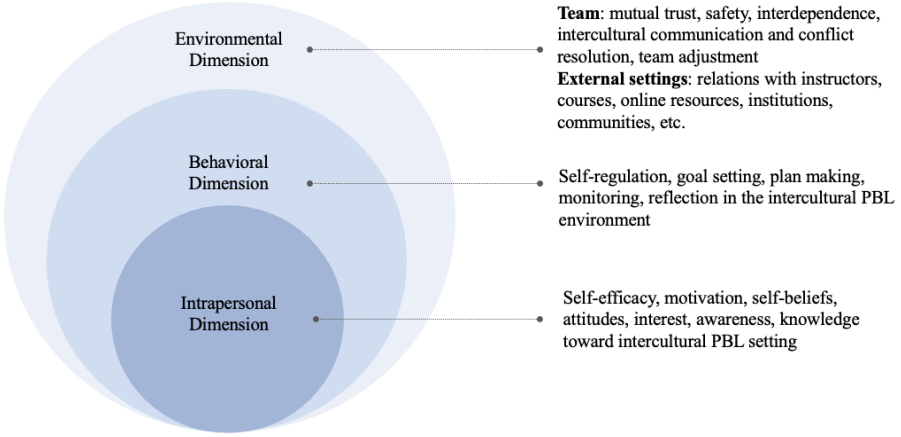

Figure 2-2 A Conceptual framework for describing learner agency in an intercultural PBL setting (amended from (Jiang et al., 2022; Jiang, Dahl, Chen, et al., 2023)

Dimension	Elements of learner agency
Intrapersonal	**Self-efficacy beliefs** • Beliefs about one's capacity to achieve higher goals (Jääskelä et al., 2017; Mercer, 2012) • Beliefs about one's ability to achieve perseverance in the face of challenges (Zimmerman & Cleary, 2006) • Beliefs about development of cultural and intercultural awareness (Beddoes et al., 2010; Ota et al., 2019) • Conceptions of professional knowledge and PBL (Du et al., 2022; Zhao & Zheng, 2014) • Beliefs about identify problems and working independently (Du et al., 2022; Zhao & Zheng, 2014) • Confidence in project work and intercultural interactions (LaFave et al., 2015; Ota et al., 2019) • Positive and negative emotions (Jokikokko, 2016; Jokikokko & Uitto, 2017; Porter & Samovar, 1996) • Cultural and engineering identity (Bergman et al., 2022) **Motivation** • Intrinsic and extrinsic motivations for exploring authentic problems from a global perspective (Nielsen et al., 2010; Shin, 2018) • Attitudes of curiosity, openness, and respect (Deardorff, 2006; Reeve & Tseng, 2011) • Motivation to learn (Reeve & Tseng, 2011) • Enjoyment of interacting with others (Zhou et al., 2011) • Interest in intercultural learning in the engineering field (Menéndez Ferreira et al., 2017)
Behavioral	**Goal setting** • Setting one's own goals and shared goals for learning (Bandura, 2006) • Having no goals or unclear goals (Du & Naji, 2021) • Goals for solving real-life problems (Vickers, 2007) **Plan making** • Challenges and coping strategies for time management (Bani-Hani et al., 2018; Ellzey et al., 2019) • Lacking the tools and skills to manage projects (Chen et al., 2021) • Making plans to fit budgets and schedules (Ellzey et al., 2019) • Improved flexibility for completing tasks (Grimheden & Strömdahl, 2004; LaFave et al., 2015) **Monitoring** • Process of coping with different challenges for better engagement (Bandura, 2006, 2008) • Process of listening, observing, communicating, and relating (Deardorff, 2006) • Activating prior learning experiences (Bown, 2009; Du et al., 2022) **Reflecting** • Process of self-reflection (Bandura, 2006) • Process of peer assessment and constructive mutual feedback (Ahern, 2010; Hökkä et al., 2017) • Feedback from supervisors and instructors (Du et al., 2022)

Dimension	Elements of learner agency
Environmental	**Team effectiveness** **a. Trust building** • Mutual support from peers (Edwards, 2011) • Developing trust in a safe environment (Du & Naji, 2021; Eteläpelto & Lahti, 2008) • Designing team contracts to build up trust (Miranda et al., 2021) **b. Team dynamic and atmosphere** • Team disagreements and conflict resolution (Borrego et al., 2013; Hökkä et al., 2017) • Inclusion of all team members (Borrego et al., 2013) • Language barriers and coping strategies (Bani-Hani et al., 2018; Wilson et al., 2019) • Developing effective communications and interpersonal relations (Nielsen et al., 2010) • Interactional and communicative challenges (Popov et al., 2022) • Team building activities (LaFave et al., 2015) • Building team responsibility (Popov et al., 2022) • Challenges of group formation (Bani-Hani et al., 2018; Guerra, 2017) **External support** • Support from teachers (Jääskelä et al., 2017, 2021) • Support from project supervisors (Du et al., 2022) • Support from local communities and industries (Borg & Zitomer, 2008; Fox et al., 2008) • Efficient utilization of facilities (Du & Naji, 2021) • Interactions with communities and institutions (Du & Naji, 2021) • Regulations and policies set by the program and institution (Du & Naji, 2021)

Table 2-2 Elements of learner agency in the intercultural PBL setting gathered from the literature.

The intrapersonal dimension comprises cognitive, affective, and motivational factors, including self-efficacy beliefs, awareness, interests, motivations, and attitudes. Among these, self-efficacy beliefs and motivation play the most influential role (Du et al., 2022; Du & Naji, 2021). Self-belief refers to the extent to which learners believe in their capacity to achieve higher goals by pitting their knowledge and skills against complex learning tasks (Jääskelä et al., 2017; Mercer, 2012), and their perseverance when confronted with difficulties (Zimmerman & Cleary, 2006). It is a dynamic and complex phenomenon which includes elements such as self-concept, self-confidence, self-efficacy, and identity (Du et al., 2022; Mercer, 2011). Moreover, it has evolved over time, and is impacted by the extent of learners' sensitivity to the environment they are situated in (Mercer, 2012). In intercultural PBL settings, learners' beliefs are strengthened if they feel that their environment supports their professional understanding and intercultural awareness (Beddoes et al., 2010), helps them gain knowledge about PBL, the engineering profession and culture in general, develop the skills required to achieve their goals (Naji et al., 2020), foster open, respectful, and curious attitudes to other cultures, and establish an engineering and cultural identity. However, learners' lack of belief in their competence, or the presence of negative beliefs, may hinder their participation in learning activities (Du et al., 2022).

The other influential factor is motivation. Motivated learners possesses the impetus, inspiration and orientation to act in their learning (Ryan & Deci, 2000). Motivation is seen as a fluid process due to the interrelation between learners' internal feelings and their external contexts (Du et al., 2022). In PBL, learners are influenced by both intrinsic and extrinsic motivations to initiate actions, self-explore problems, identify content of their learning, and manage its intensity (Shin, 2018). This context also provides learners with the motivation to interact with others in teams; this can be stimulated in multiple relational and contextual ways, including formal and informal group discussion, regular meetings with supervisors, peer support, shared learning goals, and openness (Zhou et al., 2011). The dynamic nature of motivation encourages learners to integrate their internal characteristics into wider intercultural PBL settings. In this sense, learners' desire to learn is driven by their interest in exploring problems from an international perspective, and in intercultural communication (Nielsen et al., 2010).

The behavioral dimension focuses primarily on the self-regulated characteristics of learner agency, specifically the extent to which individuals metacognitively, motivationally, and behaviorally regulate, control, and monitor their own learning (Martin, 2004; Schunk & Zimmerman, 2007). Self-regulated learning is an umbrella term for various processes such as goal setting, planning, modeling, organizing, self-monitoring and self-reflecting (Bandura, 2006; Schunk & Zimmerman, 2007). Well-regulated learners adopt goal-oriented, motivational, cognitive, and metacognitive strategies to initiate agency, generate thoughts and beliefs, and regulate behaviors in order to gain knowledge and skills and meet academic goals (Zhao & Zheng, 2014). Self-regulated learning is fostered in PBL environments. Agentic learners are proactive in identifying the resources they need, making plans to organize their project work, engaging in complex learning tasks, monitoring progress toward their goal, constructing meaning, managing their use of strategies, reflecting, incorporating feedback, and making prompt adjustments when the context changes (English & Kitsantas, 2013). In addition to the individual level, self-regulation extends to the group level in collaborative environments (Borrego et al., 2013; Du & Naji, 2021). In an intercultural PBL team, students generate common goals and plans, explore resources to promote both professional and intercultural learning, work on complex collaborative tasks, identify effective behaviors to overcome intercultural team challenges, communicate effectively, reflect on the learning process, and make further adjustments (Ota et al., 2019; Ota & Murakami-Suzuki, 2022).

The environmental dimension refers to the social and cultural settings that enable learners to achieve their goals and perform well (Bandura, 2006, 2008). Learners collaborate and interact with each other in both PBL teams and the broader socio-cultural context. Learner agency is always context-situated and relationally constructed, in that it is either supported or constrained by various factors (Jääskelä et al., 2017), of which team dynamics and external influences are key factors.

To explore proactive team features and the performance of agentic individuals, Borrego et al. (2013) identified five dimensions of PBL team effectiveness, namely: 1) avoidance of passive engagement and inclusion of all members' ideas and contributions; 2) interdependence with others to finish complex team assignments, make adjustments to plans based on peer feedback, engage in group project progression, and contribute to interdisciplinary collaboration; 3) conflict management through setting clear common goals, developing team consensus and norms, balancing the team project workload, and making decisions together; 4) efforts to build trust; 5) shared knowledge structures, which enable teams to meet expectations, coordinate actions, and adapt their behaviors. Within intercultural PBL teams, students are exposed to greater cultural diversity. Hence, all members are expected to not only address interpersonal relationships, but also to foster effective intercultural communication (Nielsen et al., 2010). They should develop appreciation and respect for other cultures, cultivate awareness of social and environmental realities, customize technology to suit different cultures(Ota & Murakami-Suzuki, 2022).

The external influences are often associated with support from other stakeholders, such as instructors, institutions, local communities, or industries (Borg & Zitomer, 2008; Fox et al., 2008). Agency is improved if students obtain external help from instructors, attend relevant courses and lectures, use facilities efficiently, and adhere to the norms and policies of programs, institutions, and communities (Du & Naji, 2021; Jääskelä et al., 2017, 2021).

To sum up, this three-dimensional conceptual framework serves as a foundation for exploring engineering students' perceptions and experiences of learner agency in an intercultural PBL context. It also advances knowledge about what elements contribute to learner agency development in such an environment. It guides the structure and organization of the methodological design in this study, especially in terms of the development of a qualitative interview protocol and a new survey instrument, data analysis, and the interpretation of empirical findings. The next chapter will introduce the context of this research and the methodological design used to carry it out.

CHAPTER 3. RESEARCH DESIGN AND METHODOLOGY

3.1. RESEARCH CONTEXT

The study was conducted in the context of higher engineering education at Aalborg University (AAU) in Denmark. This university practices PBL as a systematic approach; and the university's faculties have been dedicated to PBL for all pedagogical activities for nearly five decades. AAU's PBL model has undergone several revisions over the decades, which demonstrates a commitment from management to sustaining the full-scale implementation of PBL (Dahl et al., 2016; Kolmos et al., 2021). Four elements constituting this model have been identified, including: 1) an inclusive mix of knowledge and problem modes; 2) a variation of problem and project approach; 3) an interlinked curriculum; and 4) an explicit focus on PBL competences, such as employability skills, reflection, and critical thinking (Kolmos et al., 2021, p. 70).

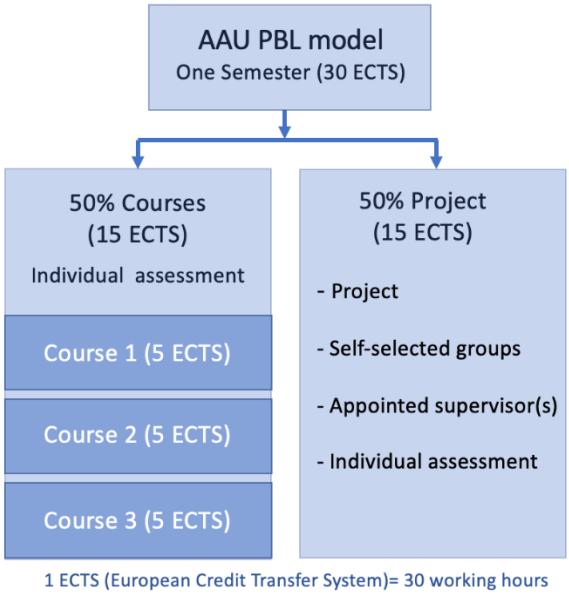

Figure 3-1 Structure of AAU's PBL model (derived from Dahl et al., 2016)

Currently, each semester at AAU is usually made up of a combination of course modules and team-based project modules, with modules of each type taking 50% of

school time (see Figure 3-1). In order for them to gain familiarity with a wide range of theories and methods involved in their projects, students participate in both compulsory and elective lectures for the first half of every semester. The courses require a significant degree of student participation in assigned exercises, group discussions and so on (Askehave et al., 2015). There are three course modules of 5 ECTS each, and students are assessed individually in these courses (Dahl et al., 2016). In addition, PBL beginners are provided with courses which focus on basic PBL theories and methods, as well as strategies for managing project work and resolving conflicts in teams. The PBL courses support students as they adapt to AAU PBL academic environment and develop professional competences. In some engineering departments, one third of students' course time is allocated specifically to PBL in their first semester (Kolmos et al., 2021).

In addition to their regular courses, students work closely in teams to manage and complete a semester project (representing 15 ECTS). This project runs in parallel with the courses and takes real-life and complex problems as the point of departure (Askehave et al., 2015). The teams are composed according to students' shared interest in project topics, and their sizes gradually decrease from an average of 6-7 members in the first year to around 2-3 members in the final semester. Each team is appointed one or more project supervisors, who provide feedback on project progression at weekly or biweekly meetings and oversee examinations. By the end of the semester, every student will attend a group-based project examination, which is primarily assessed according to their individual performance (Askehave et al., 2015).

Students are largely responsible for managing their own projects: they define their own learning goals, choose the content of the projects, determine the key elements of their study program, monitor their own progress, and organize project outcomes. Furthermore, members of project teams share relevant knowledge, decide on team roles, collectively make decisions and plans, attend regular team discussions, coordinate group learning activities, and give critical feedback to one another (Askehave et al., 2015). In recent years, in response to the increasing need for a more complex and holistic approach to problem-solving and interdisciplinarity, the AAU PBL model has accordingly increased the diversity of the types of projects that students work on. These now include not only traditional single discipline projects, but also cutting-edge interdisciplinary megaprojects; this enables students to analyze problems in a comprehensive manner, and to situate and integrate their specific knowledge, designs, or products with those of other fields (Kolmos et al., 2020).

To foster an inclusive and immersive academic environment, AAU recruits many international students every year, the majority of whom are enrolled into two-year regular Masters programs. Only two regular Bachelors programs recruit international students: chemical engineering and applied industrial engineering. Due to the international orientation of some study programs at AAU, several engineering faculties administratively place their students in intercultural teams or encourage them

to collaborate with others from different nationalities and cultures in their semester projects. This cross-cultural collaboration provides chances for both local and international students to reflect on their established ways of carrying out projects, develop different social skills relating to communication and management, and think and behave appropriately in an international context.

However, newcomers from abroad may encounter difficulties in this Danish PBL context, which involves a heavy academic workload, team collaboration, language barriers and communication issues, and pressure from different assessment systems; this can be challenging for students who lack intrinsic motivation, and students can develop problems of loneliness and isolation (Jiang et al., 2021a). Students sometimes adapt to the new culture in various ways. However, analysis has shown that instead of passively adapting to the culturally different environment, these newcomers gradually take an active and intentional role in their own learning process over time in intercultural PBL settings (Jiang et al., 2021a, 2021b). In this sense, this study is important and necessary to address engineering students' learner agency from a critical standpoint and to investigate its development throughout the students' project.

3.2. RESEARCH DESIGN

A research design consists of a planned approach to answering research questions and achieving the purpose of the research (Creswell, 2012). This study aims to explore engineering students' perceptions on their development of learner agency in an intercultural PBL setting. This overall purpose is divided into three aims: (1) to provide an overview of how engineering students work in intercultural environments, specifically when engaged in intercultural teamwork; (2) to understand a small groups of engineering students' perceptions of how their learner agency is developed and what factors influence the development in an intercultural PBL setting; and (3) to explore a larger sample of engineering students' perceptions of which elements identified in Paper 2 are crucial to support their learner agency development in such an setting. To this end, a two-phase process including both a systematic review and an exploratory sequential mixed method approach has been followed: (1) Phase 1: a systematic literature review; (2) Phase 2A: a qualitative study; and (3) Phase 2B: a quantitative study. An overview of the research design is provided in Figure 3-2.

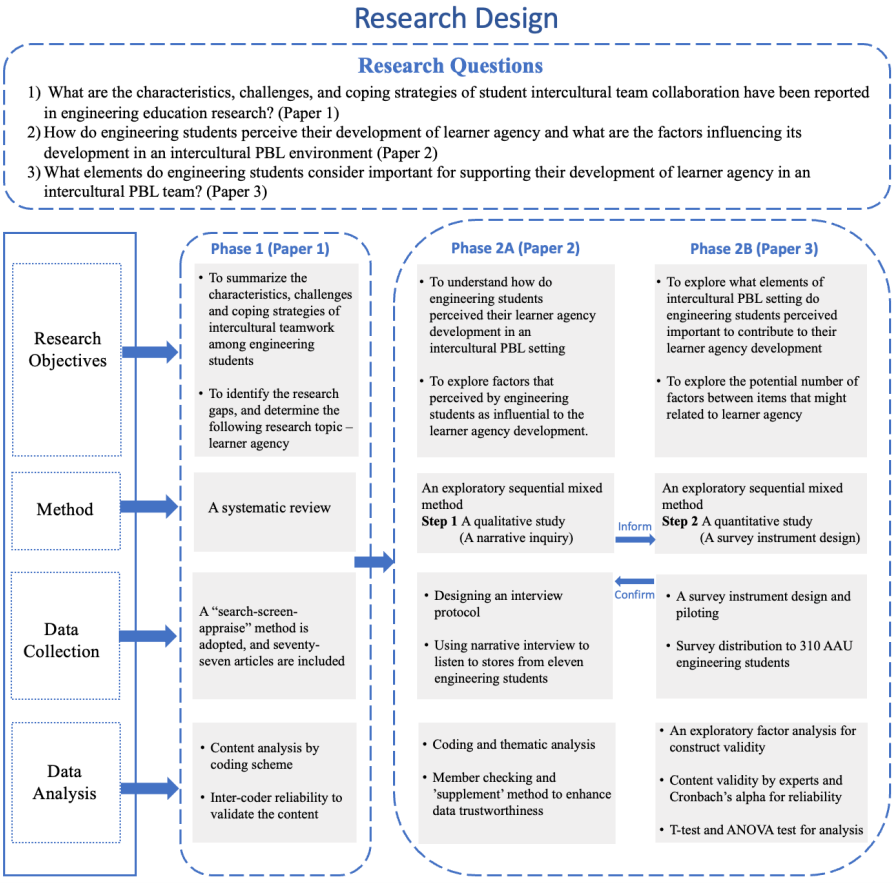

Figure 3-2 Overview of research design

3.3. PHASE 1: A SYSTEMATIC LITERATURE REVIEW

To investigate the research questions, it was necessary to take a systematic approach to comprehensively searching for, critically appraising (based on predefined criteria), and synthesizing all relevant studies of intercultural team characteristics within engineering education. According to Tranfield et al. (2003), a systematic literature review can be defined as:

> ...a replicable, scientific, and transparent process, in other words a detailed technology, that aims to minimize bias through exhaustive literature searches

> of published and unpublished studies and by providing an audit trail of the reviewers' decisions, procedures and conclusions. (p. 209).

A systematic literature review make significant contributions not only by presenting a detailed and explicit summary of existing evidence on a topic, but also by using a rigorous and scientific approach to identify research gaps (Jesson et al., 2011). Although prior studies have investigated the topic of this thesis empirically, there is still no comprehensive overview of the characteristics of intercultural team collaboration among engineering students, the challenges they encounter in such environments, and their coping strategies. This research gap inspired me to broaden our understanding on the nature of intercultural teams of engineering students. Furthermore, this review is expected to advance current knowledge on the meaning of culture, and the context, methods of preparation, learning outcomes and coping strategies of engineering students engaged in intercultural teamwork. Finally, it is hoped that this review will help engineering educators and institutions expand their understanding of how intercultural teamwork is prepared and evaluated, enabling them to set appropriate learning goals for their students. In this sense, the systematic review method was thus adopted to address the following two sub-research questions in Paper 1:

1) What are the characteristics of intercultural team collaboration that have been reported in engineering educational research in terms of formats, countries, level of collaboration, learning goals, evaluation methods and learning gains?

2) What challenges have engineering students encountered in intercultural team collaboration and what are their corresponding coping strategies?

3.3.1. DATA COLLECTION

In the planning phase, a scoping literature search and review was conducted to examine the range of the literature, identify inclusion and exclusion criteria, and select appropriate databases, search terms, and search strategies. Five electronic databases were consulted for this review: Web of Science, Scopus, EBSCO, ERIC (via ProQuest), and Engineering Village. These are either representative of databases in the engineering education field or extensive academic resources covering a wide range of research, projects, and practices. Several inclusion criteria were defined:

1) Publication year: 2000-2022
2) Language: English
3) Type of manuscript: journal articles
4) Context: higher education and engineering education
5) Type of publication: research paper, project paper, or introduction of practice
6) Topic: intercultural team collaboration of engineering students

Therefore, the search strings used in this review included: 1) inter- (or cross-, trans-, multi-); 2) cultur* (or nation*); 3) team (or group, collaboration, cooperation); 4) higher education (or HE, universit*); and 5) engineering.

The filtering and screening process depicted in Figure 3-3 followed the method advocated by Borrego et al. (2014) for engineering education, namely searching, screening and appraising articles. The included articles were initially filtered by reviewing their titles and abstracts, and then their eligibility was assessed by means of full-text analysis. The search resulted in 62 included articles after full-text screening. To ensure no relevant articles were excluded, this selection process was repeated twice. Since the electronic search method may still miss some important published studies, such as non-indexed articles (Booth et al., 2016), this review took a further step to ensure identification of relevant studies: I checked the reference lists of the aforementioned 62 studies and found 15 additional relevant studies. In total, 77 articles were deemed eligible for further analysis.

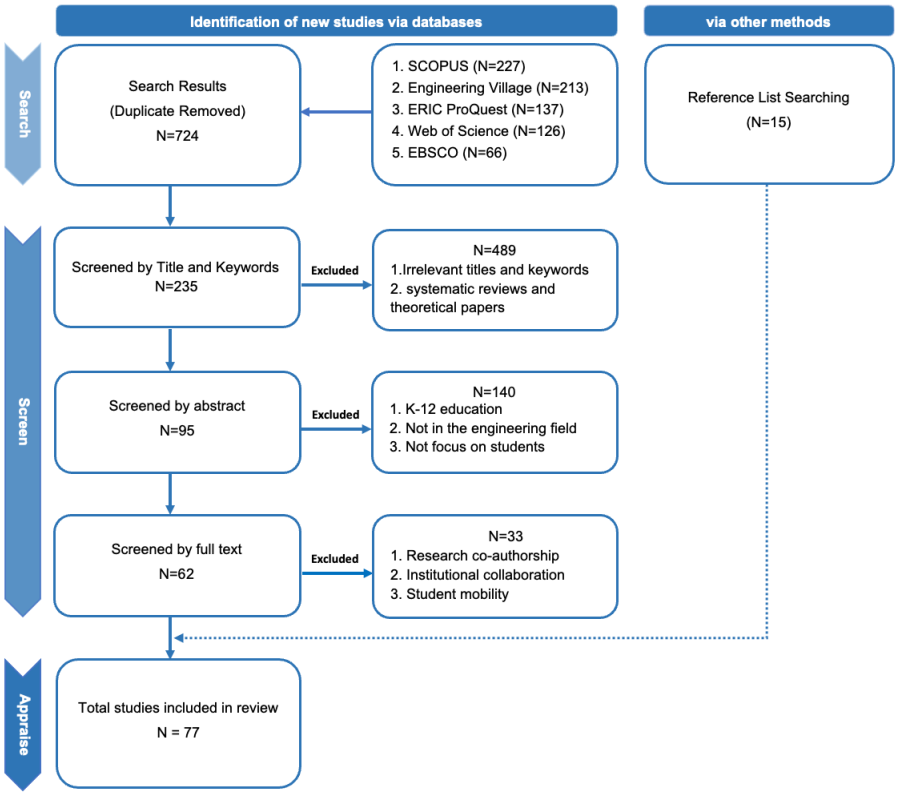

Figure 3-3 Flowchart of the filtering process (Jiang, Dahl, & Du, 2023)

3.3.2. DATA ANALYSIS

This review primarily used content analysis procedures: openly and systematically coding the content of texts, categorizing these codes into overarching themes or patterns, and reporting their frequencies (Borrego et al., 2014). An integrated approach was used, combining an inductive technique with a deductive technique.

Initial first-level themes were set up to guide the coding process, including metadata (journal name, type of collaboration, year of publication, countries and territories, and students' disciplines), research design (research purposes and methods), conceptual framework, collaboration format, group size and activities, learning objectives, learning gains, evaluation methods, challenges, and coping strategies. After the first-level themes were decided upon, the lead coder then applied an inductive open coding process to seven random articles to create a structured codebook with code names, definitions, procedures, and examples (Creswell, 2012). The initial codebook was internally discussed and refined via two rounds of internal discussions among all authors. The open codes were continuously sorted and analyzed until all the new down-level themes emerged. Open codes and themes were analyzed using NVivo 12, which allowed researchers to collaborate on data analysis and share data and results with each other.

3.3.3. DATA VALIDITY

To strengthen the validity of the search, three librarian experts were invited to evaluate the search keywords and the appropriateness of specific electronic databases. The search terms were refined accordingly. In addition, several approaches were used to validate the data analysis process. First, all selected papers were read iteratively multiples times, which enabled researchers to consider in depth whether codes and themes were related to the text. Then, the leader coder and two other experts internally discussed and revised each code for several rounds and reached some agreement. Inter-rater reliability (IRR) was then used to determine the extent to which two or more independent coders agreed on the same content (Belur et al., 2021). To measure IRR, we randomly choose five articles and invited an external graduate student to review all the open codes of these articles. As a result, 213 out of 247 codes were agreed upon, an acceptance rate of over 86%. Finally, points of disagreement were again discussed by all the researchers involved in this study, and the codes were then revised.

While this systematic review takes a relatively rigorous approach to the synthesis of evidence on intercultural teamwork among engineering students, the process of data collection, analysis, and validity of this study could have been improved. First, publication availability bias occurred because the search was restricted to peer-reviewed journal articles written in English in only five databases. Other databases and sources such as conference papers, journals in languages other than English, non-

academic reports and articles, contributive theses and dissertations, grey literature, and so on, could have been consulted. Second, despite thorough search strategies, some relevant studies may have been left out, especially if they were published in non-indexed journals, were not available electronically, or were not easily accessible. Although the reference lists of 62 studies searched and screened from five databases were examined during this study, other methods such as searching key journals, author searching and citation searching, as recommended by Booth et al. (2016), could also have been adopted. Third, researcher bias occurred due to subjectivity in the selection of samples and the extraction of data. Several efforts have been made to reduce this bias by consulting three librarians on search terms, discussing coding over multiple rounds with other authors in Paper 1, and inviting an external expert to determine inter-coder reliability. However, bias in the title, keyword and abstract screening processes could have been reduced by inviting more researchers to check that no relevant articles were mistakenly removed and coding the same transcripts multiple times across a timeline and calculating intra-coder reliability.

3.4. PHASE 2: AN EXPLORATORY SEQUENTIAL MIXED METHOD

The systematic review mentioned above helped me gain a general understanding of engineering students' perceptions about the characteristics and challenges of intercultural teamwork. One of the research gaps identified relates to the cognitive and affective development of students and their actual engagement in intercultural practices, as well as their actual interactions with broader settings. This underlines a need to encourage engineering students to be more proactive when they participate in intercultural teamwork on how to make independent choices, take ownership of authentic tasks, and develop their agency. Therefore, this systematic review study narrows down my research focus in Phase 2 to analysis of the topic of learner agency within an intercultural PBL setting by means of empirical research design. Specifically, an exploratory sequential mixed method design was adopted in this phase.

The study reported here proceeded in two steps. The first step begins with the collection and analysis of qualitative data for exploratory purposes, to gain an in-depth understanding of my research topic. This is followed by the second step to collect and analyze quantitative data using a large sample so that the results can be generalized (Creswell, 2009). This mixed method enabled me to combine the strengths and address the limitations of both qualitative and quantitative methods.

Before conducting data collection, a literature review on learner agency, PBL, and intercultural learning was conducted to establish the current state of knowledge on these two concepts and identify gaps in the literature. Furthermore, the review helped

me refine the research questions and create the analytical tools, which were inspired by various theories and viewpoints. Through this process, a three-dimensional conceptual framework with multiple elements for describing learner agency in intercultural PBL settings was developed. This framework guided the exploratory sequential mixed method design of this research. More specifically, it guided the interview protocol development and qualitative data analysis, as well as a source of inspiration when designing the survey instrument items. This section will explain how the qualitative study was conducted, while the quantitative study will be elaborated upon in section 3.4.2.

3.4.1. PHASE 2A: A QUALITATIVE STUDY

3.4.1.1. METHOD: NARRATIVE INQUIRY

A qualitative study using the narrative inquiry method was constructed to investigate the two research questions in Paper 2 (how engineering students perceive their development of learner agency, and the factors that influence that development in intercultural PBL environments). This study not only contributes to current knowledge on learner agency, engineering students and intercultural learning, but also broadens my understanding of what elements of learner agency support agency development in intercultural PBL settings by analyzing students' personal narratives.

Narratives are powerful tools for understanding one's experiences, lives, and beliefs through storytelling (Clandinin & Huber, 2010). They also explore the meanings behind the social and cultural contexts in which these stories are produced and shared; as Clandinin (2013) stated,

> …the focus of narrative inquiry is not only valorizing individuals' experience but is also an exploration of the social, cultural, familial, linguistic, and institutional narratives within which individuals' experiences were, and are, constituted, shaped, expressed, and enacted. (p. 18)

The methods used for narrative inquiry include in-depth interviews with participants, life histories, written narratives, focus groups, and the analysis of language and structure (Elliott, 2005). In this study, narrative interviews were used to establish a comprehensive overview of how engineering students behave in intercultural teams, reflect on their PBL experiences, and develop agency. In order to link the personal experiences of students with their environments, the three perspectives on narrative inquiry proposed by Clandinin and Connelly (2000) were taken into account: temporality (students' reflections on their past, present and future experiences), sociality (students' interactions with others), and spatiality (the contexts which shape students' experiences).

3.4.1.2. PARTICIPANTS AND DATA COLLECTION

A purposive sampling technique that included the snowballing method was used to recruit engineering students at AAU who met the criterion of having worked in a culturally mixed project team for at least one semester (Creswell, 2012). After receiving ethical approval from the relevant institutions, an invitation email was sent to approximately fifty students in different engineering faculties including electronic engineering, architectural engineering, computer engineering and so on. In the end, eight students consented to participate. We also asked these eight participants to identify other students who might participate. Only three additional participants were chosen from the resulting list of ten recommended participants, due to data saturation having been reached after examining the transcripts. Major themes had been recognized, and no significant changes could be made to the codes or to the details of existing themes.

In total, eleven graduate students were included in this qualitative study. Table 3-1 shows basic information about all participants. Their names are pseudonyms, and any identifiable data are removed to ensure confidentiality. The participants were relatively representative in terms of gender, nationality, and disciplines. Based on their prior experience with PBL and their academic year, they were categorized into three classes of learners: beginner, novice, and experienced learners.

No.	Name	Gender	Nationality	Engineering discipline	Year of program	Prior PBL experience before Masters	Type of PBL learner
1	Erik	Male	Spanish	Mechanical	1	No	Beginner
2	Ida	Female	Chinese	Computer	1	No	Beginner
3	Sofie	Female	Indian	Electronic	1	No	Beginner
4	Alfred	Male	Spanish	Electronic	2	No	Novice
5	Lucas	Male	Chinese	Energy	2	No	Novice
6	Mads	Male	Indian	Electronic	2	No	Novice
7	Olivia	Female	Spanish	Architectural	1	Yes	Novice
8	Belle	Female	Polish	Architectural	1	Yes	Experienced Learner
9	Clara	Female	Danish	Environmental	1	Yes	Experienced Learner
10	Karl	Male	Danish	Architectural	1	Yes	Experienced Learner
11	Theo	Male	Danish	Industrial Design	1	Yes	Experienced Learner

Table 3-1 Basic information about participants (Jiang et al., 2022)

Narrative interviews allow participants to share their stories without being prompted with specific questions or topics. The researcher may ask open-ended questions to

encourage the participant to elaborate on their experiences and to explore different aspects of their story (Kvale & Brinkmann, 2015). Several procedures are conducted during the data collection process.

Initially, a semi-structured interview protocol was designed. The interview questions were discussed by the research group and two experts in qualitative research. Accordingly, the questions were refined to follow a narrative interview structure. The detailed protocol is shown in Appendix A. Using convenience sampling, a Danish student from mathematical engineering was invited for a pilot interview, and some potential probing questions were prepared. The interview began with some questions about the participants' background, such as their major, department, academic year, and so on. In accordance with the structure of the conceptual framework, general questions were posed to start conversations in each dimension, and were accompanied by several probing questions relating to different dimensions of agency to let students tell their own stories. Table 3-2 shows both the general and probing questions.

Dimensions	General questions	Probing questions
Intrapersonal	1.How do you understand PBL? (What does PBL mean to you?) 2. How do you feel about working with people from different countries/backgrounds on the project?	**Self-efficacy beliefs** • How do you believe your intercultural PBL experience affects you and your future? **Prior experience** • How have you previously experienced PBL? • How did that influence your current PBL team project work? **Motivation** • Based on your experience, what contributed to your motivation to learn in an intercultural environment at AAU? **Interest** • How does the current PBL project and the team interest you? • Are you interested in working in an intercultural team? If so, could you please elaborate more on your interest?
Behavioral	3. Could you please tell me about your project?	**Goal setting** • Do you have any personal goals and common learning goals with your team? Could you elaborate on this? **Plan making** • How do you make plans to manage your project? **Monitoring** • What challenges that you have encountered when working in an intercultural team? • Have you encountered any unexpected experiences? If so, could you please elaborate more on this? • How do you cope with these challenges? **Self-reflecting** • How did you self-evaluate your project work within your team? How do you encourage each other to self-reflect?

Dimensions	General questions	Probing questions
Environmental	4. Could you please share your story of how you work in an intercultural team? 5. What support did you receive to work in an intercultural team? and what did you do to contribute to the teamwork overall?	**Team interaction** • What do you feel or think about the atmosphere in your team? • What do you do within the team to build trust with each other? • Have you experienced any disagreements or conflicts with your teammates? If so, how did you cope with that and reach consensus? • How do you communicate with your teammates? • What did you do to achieve efficient communication? • What team roles have you played in your team? **External support** • Did you get sufficient support from your supervisors? If so, what support that you get? • What other support did you receive or seek to make the intercultural team function?

Table 3-2 Sample questions from the interview protocol

In addition, the temporal, social and spatial dimensions of narrative inquiry proposed by Clandinin and Connelly (2000) guided me to ask for participants' reflections and nuances on their past experiences, present engagement and future orientation, as well as their interactions with culturally different team members. For instance, concerning temporality the second-year students were asked to reflect on the differences between their experiences in the first, second and third semesters. They were also asked about their future career plans and goals. The PBL beginners were asked to narrate the differences between how they felt about project work and team collaboration at the beginning and the end of the semester. Regarding the perspective of sociality, Danish students were asked about differences between their interactions with an international group and a local group. In terms of spatiality, international students were asked to make comparisons between their learning experiences in their home country and in Denmark.

The eleven interviews ranged from 60 to 80 minutes in duration and were conducted primarily in English. The participants were interviewed near the end of the semester, which allowed them to narrate their experience of intercultural teamwork and reflect on the entire semester project process. Two participants were interviewed over MS Teams or Zoom, while the rest engaged in interviews in person. With the participants' permission, these interviews were audio-recorded and fully transcribed.

3.4.1.3. DATA ANALYSIS

During the interviews, short notes were taken to highlight interesting details. Then, each interview was promptly transcribed and briefly analyzed before the next interview was undertaken. This iterative practice enables researchers to reflect in depth on each participant's narratives, and revise the follow-up questions accordingly as new themes and issues emerge from the initial data analysis (Gilbert, 2008). In total, the 11 transcribed interviews amounted to 213 pages, and the notes numbered 15

pages. Each transcription was read closely twice while listening to the recording, to ensure the conversation had been transcribed correctly.

Floyd (2012) suggest a coding and thematic analysis technique for analysis of narrative inquiry data. Using NVivo 12, an integrated approach which combined both deductive and inductive techniques was taken. A priori codes were generated from different elements of our three-dimensional conceptual framework: intrapersonal, behavioral, and environmental. Open, axial, and selective coding was used for inductive analysis (Creswell, 2012). During axial coding, these open codes were connected to each other, and cross-case comparisons were made. Using a selective coding scheme, these codes were sorted, revised, and organized into overarching themes or categories. Initially, 210 open codes emerged. Open codes with similar or redundant information were further integrated, compared, and connected, resulting in 63 subthemes. This made the codebook more explicit and structured. For instance, several open codes were merged into the subtheme "Have intrinsic desire for improving intercultural competence" including students' desire to increase their English proficiency, interest in communicating with different groupmates, wish to better understand different views, eagerness to learn about different cultures, and so on.

These 63 subthemes were then analyzed and discussed with other co-authors in Paper 2 to see if they corresponded to the conceptual framework. These were further sorted and organized. At the end of this process, three themes remained in the intrapersonal dimension, four in the behavioral dimension and three the in environmental dimension. In total, 10 themes with 45 deductive subthemes were generated from the conceptual framework in Figure 2-2 and 18 inductive subthemes were generated through thematic analysis. These are shown in Table 3-3.

Dimension (First-level codes)	**Theme (Second-level codes)**	**Subtheme (Third-level codes)**	
		Deductive subthemes	**Inductive subthemes**
Intrapersonal	Self-efficacy beliefs	1. Develop beliefs in the ability on independently complete projects 2. Develop beliefs in the ability to achieve the learning goals 3. Improve confidence in intercultural teamwork and communication 4. Improve confidence in solving complex and practical problems 5. Develop cultural awareness 6. Gain professional and cultural knowledge 7. Gain understanding on a wider range of views	1. Promote transferable skills applied in a new cultural setting

Dimension (First-level codes)	Theme (Second-level codes)	Subtheme (Third-level codes)	
		Deductive subthemes	**Inductive subthemes**
	Motivation	8. Stimulate interest in exploring real-life problems from an international perspective 9. Increase interest in working with people from other cultures 10. Have extrinsic motivations for learning 11. Have intrinsic desire for improving intercultural competence 12. Gain an interest in the topic of the project	2. Shift motivations from extrinsic to intrinsic
	Sense of identity as a global engineer		3. Identify with the profession as an engineer working in an international company 4. Identify with the profession as an engineer working in a local company with international colleagues 5. Identify as an international engineer working in Denmark
Behavioral	Goal setting	13. Have challenges in setting up a personal and team learning goal 14.Use coping strategies and goal setting	6. Take responsibility for helping the team set goals 7. Set up goals together as a learning process
	Plan making and project management	15. Challenges in managing the project 16. Improper time scheduling 17. Time management strategies 18. Flexible task distribution	8. Micromanagement challenges 9. Taking a more active role in organizing the division of work
	Monitoring	19. Language barriers 20. Different ways of thinking, communicating, and working 21. Disagreements about project work 22. Unpredictable results and ever-changing project directions 23. Overcoming language issues to increase engagement 24. Increasing communication and clarification to reach group compromise 25. Activating prior PBL experience	10. Deciding team roles through personality tests 11. Unfamiliarity with terminology and jargon 12. Activating prior international experience
	Evaluation and reflection	26. Supervisors' feedback on work progress 27. Peer feedback during the project process 28. Self-reflection on project work	13. Feedback and evaluation from users or customers

Dimension (First-level codes)	Theme (Second-level codes)	Subtheme (Third-level codes)	
		Deductive subthemes	**Inductive subthemes**
Environmental	Trust building	29. Developing trust and friendship 30. Mutual respect for each other 31. Team contracts that contain a set of rules	14. Finding groupmates with whom one has worked well before 15. Experiencing distrust due to reduced personal contributions and lower levels of professionalism
	Team atmosphere	32. Mutual help and support 33. Building a closer interpersonal relation in the team 34. Building effective intercultural communication 35. Developing an openness to others' cultures and viewpoints 36. Extracurricular activities and social gatherings 37. Discussing cultural differences 38. Lacking collaborative spirit and miscommunication 39. Experiencing conflicts and disagreement 40. Forming groups 41. Building more team responsibility 42. Developing an inclusive team	16. Inability to handle team competitiveness and stress 17. Making more efforts to collaborate online during the COVID-19 pandemic
	Support from supervisors and institutions	43. Getting support from project supervisors 44. Getting support from teaching assistants and lecturers 45. Getting less support from the university	18. Getting support from engineering departments

Table 3-3 Themes and deductive and inductive subthemes in three dimensions

The temporality, sociality and spatiality of narrative inquiry were considered during the analysis. Take the second-year Indian student Mads as an example. In terms of temporality, he reflected on and compared his intercultural PBL experiences across three semesters. Without prior PBL experience, he had no belief in his ability to finish the semester project (coded as deductive subtheme 1 in Table 3-3), and no experience of setting goals to meet project deadlines (coded as deductive subtheme 13). After getting guidance from supervisors and his Danish groupmates, he narrowed down his project focus and learned to set some timelines for each task (coded as deductive subthemes 17, 32, 43). In his second year, all the courses and project work were conducted online. He experienced online fatigue, silent groupmates, and insufficient conversation with his group (coded as deductive subtheme 38 and inductive subtheme 17). However, in the third semester, he worked physically with the same groupmates. He found that his projects became more structured and efficient, and he became more active in managing a group project and pointing out problems to his groupmates directly (coded as deductive subthemes 27, 28 and inductive subtheme 9). In relation to sociality, he described cultural and personal influences on his experiences by comparing his habits in India and Denmark. For instance, he used to be relaxed in the

morning and start school at 9:30 a.m. in India. But he found it challenging to adapt to starting work at 8:15 a.m. in Denmark (in deductive subthemes 15 and 17). The food was also different. He stated that his European groupmates ate cold lunches and large dinners, while he was used to eating more for breakfast and preferred warm and spicy food for lunch (in deductive subtheme 37). Regarding spatiality, since neither Mads nor his groupmates seemed to experience much international life or receive any structured education about culture, their methods of communication were not conducive to mutual understanding. It took them a long time to negotiate and achieve effective communication (in deductive subthemes 34 and 38).

3.4.1.4. TRUSTWORTHINESS

To enhance trustworthiness, each code and theme was discussed by the research group and the two experts in qualitative methods over several rounds and refined until a consensus was achieved. Member checking was also adopted as a validation method that minimizes the researchers' bias and checks the accuracy of participants' accounts (Creswell, 2012). Due to the final exams, only four students (two locals and two internationals) were available to assess the validity of the findings. They confirmed that the summarized findings adequately and accurately reflected their viewpoints.

Instead of triangulating participants' narrations using different data sources, the "supplement" method detailed by Floyd (2012) was used to balance individuals' subjective opinions and increase trustworthiness. Accordingly, documents such as curricula, lists of regulations and the details of international collaborative programs in different engineering faculties were compared with the interview transcripts, and subsequently analyzed and discussed with the research group members.

This study focuses on engineering students' perceptions of how learner agency is developed using different elements. By doing so, it assumes that all students have the potential to develop agency but ignores the fact that they may adopt passive approaches. Furthermore, I am aware that the claim of "development" was only studied in terms of the students' retrospective self-reflection, rather than examining their perspectives before and after engaging in PBL in intercultural teams. The interviews could have been performed in two to three rounds with the same participants during their study to better explore the timeline of their development. Since some students only experienced their intercultural PBL journey for one semester, multiple interviews may have provided better insights into the temporality of their narratives and helped me understand whether they actually developed their agency in different intercultural project teams. The trustworthiness of the interview results could be improved by inviting an external expert to independently code the same transcripts with me and then calculating inter-coder reliability. It could also be enhanced by me coding the same transcripts multiple times across a timeline and calculating the intra-coder reliability.

3.4.2. PHASE 2B: A QUANTITATIVE STUDY

While Paper 2 provides insights into students' experiences and views on their learner agency development and identifies several supportive elements of learner agency in an intercultural PBL context, it fails to provide an overview of a large group of students' perceptions, and of which elements are more important. Therefore, a quantitative study employing a survey instrument was used to explore the bigger picture, and aims to explore which of the supportive elements identified in the qualitative study that a larger sample of engineering students considered more important to support their learner agency development. An instrument is "*a tool for measuring, observing, or documenting the quantitative data…the instrument could be a test, questionnaire, tally sheet, log, observational checklist, inventory, or assessment instrument*" (Creswell, 2012). Several demographic variables, such as gender, nationality, academic year, and level of experience with PBL, are also discussed in Paper 3.

3.4.2.1. PROCEDURES OF INSTRUMENT DESIGN

Instrument design began with a developmental stage in which the domain of content was identified through a comprehensive literature review (Lynn, 1986). The conceptual framework, elements of learner agency mentioned in prior literature, and the findings from the previous qualitative studies served as an initial foundation for the development of the items in the instrument, resulting in a pool of 55 items in the first round. Figure 3-4 shows a flowchart of procedures and timeline of instrument design.

Next, these items were discussed internally within the research group over several rounds. Twenty-five irrelevant and redundant items were removed, and thirty items were retained for review by three international experts. These experts had extensive experience with PBL research, engineering education research and intercultural studies. On the basis of these reviews, revisions were made to the survey question, introduction, three open-ended questions, and eight statement items. One item pertaining to team contracts was removed and two items relating to external resources were added. The initial three dimensions were further split into four dimensions: intrapersonal, behavioral, team building and external support. The instrument had a total of 31 items and was proofread by a native English speaker to correct language errors.

Convenience and snowball sampling was used to select six local and four international students who had studied in AAU PBL environments for at least one year. These ten students piloted the instrument. Following their suggestions, the grammatical subject of each item was changed to the first person, for example "I", "we" or "my team", and the sequence of these items was revised accordingly.

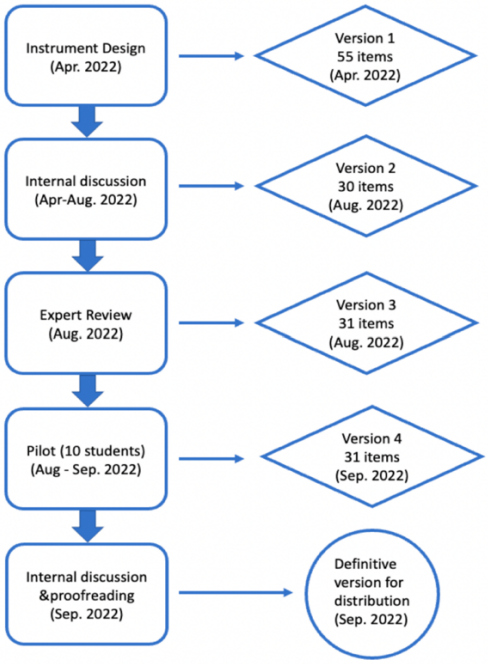

Figure 3-4 Flowchart of instrument design (from Jiang, Dahl, Chen, et al., 2023)

The research group then discussed these items again before a final version with 31 items was decided upon and reviewed by a native English proofreader. The sample elements under each dimension are shown in Table 3-4. This was intended to investigate the following question: "Based on your recent experience in an international team project, in which ways have the following aspects been helpful to work in this environment?" Students had to rate the helpfulness of each item on a scale of 1-5, ranging from "not at all helpful" to "most helpful". Three sections were included in the survey, as follows:

Section 1: Demographic data (gender, nationality, year of study, duration of PBL experience)

Section 2: 31 items to be answered using a 5-point Likert scale

Section 3: Three open-ended questions (which items are the most helpful; which items are the least helpful; further comments that are not included in the survey)

Dimensions	Sample elements
Intrapersonal dimension	- Prior experience/awareness - Self-efficacy beliefs - Motivation and interest
Behavioral dimension	- Goal setting - Planning - Monitoring - Evaluating
Environmental dimension (Team building)	- Team trust - Team atmosphere - Team dynamic - Peer support
Environmental dimension (External support from outside the PBL team)	- Supervisor support - Study program support - Others

Table 3-4 Basic elements of survey items

3.4.2.2. SAMPLING AND DATA COLLECTION

After receiving institutional ethical approval from AAU, an email with a survey link was sent to secretaries or study coordinators at all engineering and technology faculties who offered international programs. They invited students who were eligible for the survey to participate, and 178 valid responses were received. In an effort to increase the response rate and achieve a balance of students' nationalities, engineering programs and genders, the survey was also distributed in person on paper. This facilitated an additional 132 valid responses. A total of 310 responses were thus considered for further data analysis. All students had given their consent before filling out the survey, either by clicking on a consent button or signing a paper document. Details of the participants' demographic information are provided in Paper 3.

3.4.2.3. PROCEDURES OF DATA ANALYSIS

Several efforts were made to measure the survey instrument data. All data were initially analyzed using SPSS Statistics (version 28). Exploratory factor analysis (EFA) was then conducted to reduce the number of independent items to a smaller set of summary variables or factors, and to explore the underlying theoretical structure (Fabrigar & Wegener, 2012). Content validity (through expert review), construct validity (via EFA) and reliability (using Cronbach's alpha) were analyzed.

Furthermore, several descriptive and demographic results were gathered using the t-test and analysis of variance (ANOVA) statistical methods.

VALIDITY

Both content validation and construct validation were undertaken on EFA. Content validity was achieved primarily through experts' evaluation and piloting of the instrument (DeVellis, 2012). As mentioned in section 3.4.2.1, three experts and ten students were invited to comment on the content of the instrument.

EFA was used for construct validation, which is the examination of the extent to which a set of variables reflect a theoretical structure (DeVellis, 2012). Following the procedures used in prior studies on EFA, several statistical and methodological procedures were conducted for construct validity. These were: (1) data inspection techniques; (2) the factor extraction method; (3) the factor retention method; (4) the factor rotation method; and (5) the factor loading cutoff (Howard, 2016; Taherdoost et al., 2014).

First, to determine whether sufficiently large relationships existed within the data, both the Kaiser-Meyer-Olkin (KMO) and Bartlett tests were conducted. The KMO value was 0.827, which is regarded as good and acceptable, and Bartlett's test of sphericity was significant ($p<0.001$). These results indicated that the data was appropriate for further factor analysis.

Second, the factor extraction method, which included principal component analysis (PCA), principal axis factoring (PAF) and maximum likelihood (ML), was performed to extract initial factors. These are the three most widely used extraction methods for EFA (Beavers et al., 2019; Howard, 2016). The three methods were compared at a later stage to select the method that most accurately described the data.

Third, several efforts were made to decide how many factors should be retained. To begin with, PCA, PAF and ML all provide an initial extraction solution of nine factors. Based on the Kaiser criterion, these nine factors were retained due to having eigenvalues greater than 1.00. However, by performing a different extraction method, and setting a factor cutoff value of 0.40 as acceptable, three factors were found to only contain one or two items, which is generally seen as weak and unstable (Taherdoost et al., 2014). In this case, nine factors may not be the best solution. A visual scree plot (VSP) was then adopted for factor retention. Each eigenvalue for a different number of factors is shown in Figure 3-5. Factors with an eigenvalue before the successive eigenvalues becoming less noticeable is retained, as these factors are deemed to represent common variance significantly better (Howard, 2016). Hence, both four and five factors were selected as a solution. To further prove this assumption, parallel analysis was performed, and five factors were found to produce the best outcome and retain the most information after eliminating the factors with the fewest items.

Fourth, the varimax rotation method was compared with direct oblimin. Varimax rotation aims to increase the variances of factor loadings, whereas direct oblimin directly rotates to the final solution, and specifies the extent to which factors may correlate (Browne, 2001; Howard, 2016). The comparative results are shown in Table 3-6.

Fifth, following Floyd & Widaman (1995) and Senocak (2009), who took 0.40 as an acceptable factor loading cutoff, this study retained items with a factor loading greater than 0.40. Furthermore, a correlation matrix between the items were conducted to evaluate how strongly each item correlated with other items. Prior studies suggested retaining items with a correlation matrix value over 0.30 (Tabachnick & Fidell, 2001; Taherdoost et al., 2014). As a result, five out of 31 items were removed due to low factor loading values and low correlation matrix values. After removing these five items, no cross-loading items were found, indicating that each item strongly reflected its corresponding factor. The factor loading results using different extraction and rotation methods are shown in Table 3-6. The factor loading results are arranged in order of PCA and varimax rotation results. The remaining results are arranged in the same order to facilitate comparison. Compared with the other two extraction methods, PCA retained the most items. When performing varimax rotation compared to direct oblimin, no real difference was observed in the items pertaining to each factor. Therefore, PCA was selected for use in this study, and the varimax rotation technique was randomly chosen to show the factor loading results.

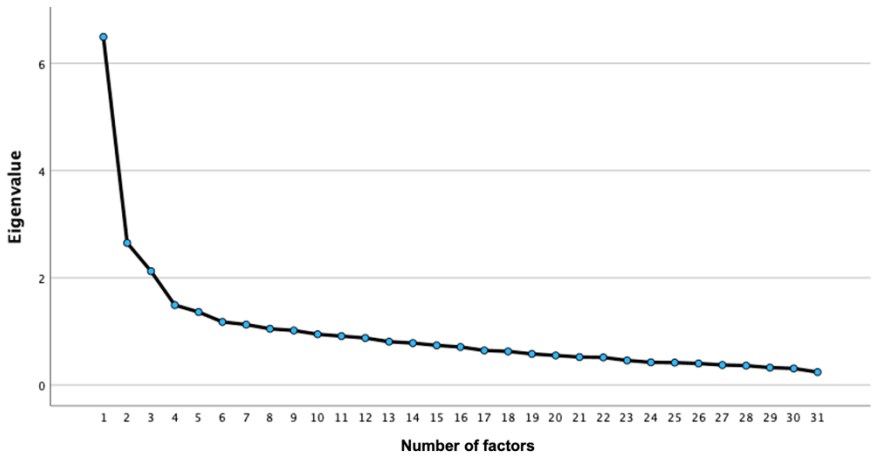

Figure 3-5 Scree plot of eigenvalues for each number of factors

The analysis indicated that the subject of the instrument is best explained by five factors: interest and motivation (factor 1), self-efficacy (factor 2), self-regulated behaviors in teams (factor 3), team dynamics (factor 4), and external support (factor 5). Ultimately a total of 26 items were retained for further statistical analysis. These

items under five factors also correspond to the three-dimensional conceptual framework of this study. The final factor loading results are shown in Table 3-5.

RELIABILITY

Internal consistency was calculated using Cronbach's alpha to demonstrate the instrument's reliability. In some previous literature, 0.6 is considered an acceptable Cronbach's alpha for a survey at an explorative stage. From instance, Tabachnick and Fidell (2001) and Taherdoost et al. (2014) considered values in the range between 0.6 and 0.8 moderate but acceptable. In Taber (2018), values of 0.64 – 0.85 were described as adequate and values of 0.61 – 0.65 as moderate. DeVellis (2012) also stated that values between 0.65 and 0.70 were minimally acceptable for scale development. In this study, Cronbach's alpha value shown in Table 3-7 for each factor was between 0.651 and 0.808, indicating an acceptable level of reliability for all factors.

DESCRIPTIVE AND DEMOGRAPHIC STATISTICAL ANALYSIS

To report both descriptive and demographic statistics, Cohen's value was used to measure the effect size of each factor (Cohen, 1988). The statistical significance of several independent variables was also calculated, using both a t-test and analysis of variance (ANOVA). One-sample t-tests determine whether the mean of an unknown population differs from a specific value. Paired sample t-tests were performed to compare the means of different factors. Independent-samples t-tests compare the means of two independent groups, while ANOVA tests compare the variances across the mean of three or more independent groups (Muijs, 2004). Some statistical analysis results are provided in Paper 3 and further elaborated in Section 4.3.

This study only performed EFA for several reasons. First, the current datasets (N=310) might have the potential to test further psychometric properties of the scale such as confirmatory factor analysis (CFA) to cross check and confirm the EFA result. However, when splitting the random number of current participants to run both EFA (normally 50% participants) and CFA suggested by Orcan (2018), the KMO value in EFA with only 155 participants is 0.6, which did not reach the acceptable level for EFA. Furthermore, the other half for performing CFA also did not support me to do further analysis for scale validation in this round. Second, in EFA, the sample size has an impact on the precision of all statistically estimates, and the factor pattern dependent by a larger scale factor analysis generate more stable results (DeVellis, 2012; Kyriazos, 2018; Thompson, 2004). Prior studies pointed out that most authors are accepting of a minimum sample size of 200 and regarded 300 participants and above as a good sample size for EFA analysis (Costello & Osborne, 2005; DeVellis, 2012; Howard, 2016). In this sense, Paper 3 decided to analyze all 310 participants to ensure the stability of the emerging number of factors. Third, the purpose of the study is not to validate the scale, but to explore the number of factors emerged between the

items and what emerging factors that students perceived as important to support their agency. Therefore, EFA in this stage is sufficient if my purpose is not to further validate the scale. However, an examination of psychometric properties of the scale is still needed in the future studies. It thus provides me with the future research direction even after this PhD study on validating the scale by collecting the new dataset for performing CFA.

Item	Components				
	1	2	3	4	5
Factor 1- Interest and motivation (IM)					
IM 1 Working in an international team interests me	0.722				
IM 2 I welcome the diversity inherent in working in an international team.	0.700				
IM 3 I believe my international team experience could prepare me for future work in a global context.	0.670				
IM 4 In my international team, I am motivated to explore problems in a global context.	0.593				
Factor 2 - Self-efficacy (SE)					
SE 1 I have knowledge about my team members' background at the project start.		0.633			
SE 2 I know what it takes to work in an international team.		0.587			
SE 3 I have prior experience of working in an international team.		0.528			
SE 4 I am confident in my ability to overcome challenges in my international team		0.502			
SE 5 I am capable of working with people from different backgrounds.		0.495			
SE 6 I am able to take initiatives throughout the process of working on the project with my international team.		0.459			
Factor 3 - Self-regulated behaviors in teams (SB)					
SB 1 In my international team, we set up common learning goals at the project start.			0.788		
SB 2 We make plans according to our learning goals in my international team.			0.784		
SB 3 We regularly check up on the team plans to ensure they have been followed.			0.626		
SB 4 We self-evaluate our project process according to our learning goals.			0.571		
SB 5 We adopt time management strategies to organize projects.			0.527		
Factor 4 - Team dynamics (TD)					
TD 1 In case of unexpected issues, we meet together immediately to discuss solutions.				0.695	
TD 2 We provide constructive feedback to each other.				0.674	
TD 3 My team encourages each member to speak out.				0.667	
TD 4 We adjust our plans according to the project process.				0.661	
TD 5 My team makes efforts to constructively handle team conflicts.				0.648	
TD 6 We support each other so no one lags behind.				0.617	
TD 7 My team encourages diverse individual opinions in our project.				0.535	
Factor 5 - External support (ES)					
ES 1 We are guided by our project supervisor regarding how to work in an international team.					0.676
ES 2 We use online resources (e.g., YouTube, online courses) to learn more about how to work in an international setting.					0.656
ES 3 We are offered training activities organized by the university/faculty on how to work in an international team.					0.637
ES 4 We are provided needed resources (e.g. materials, facilities) for our international project teamwork to function from our study program.					0.598
Removed items					
1. We meet regularly to work together on the project.					
2. My international team is formed by common interests in the project topic.					
3. We work on project tasks which are distributed by individual strengths.					
4. We take turns to serve as team leaders.					
5. We make efforts to improve our communication skills in an international team.					

Table 3-5 Factor loading results for EFA

Table 3-6 Comparative results of different factor extraction and rotation method

	Principal Component Analysis (PCA)										Principal Axis Factoring										Maximum Likelihood									
	Varimax Rotation					Direct Oblimin					Varimax Rotation					Direct Oblimin					Varimax Rotation					Direct Oblimin				
Items	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5	F1	F2	F3	F4	F5
IM 1	.722					.734					.662					.688					.673					.698				
IM 2	.700					.720					.581					.611					.570					.597				
IM 3	.670					.691					.550					.574					.554					.575				
IM 4	.593					.590					.508					.511					.506					.508				
SE 1		.633					.660					.408					.427					-					-				
SE 2		.587					.562					.510					.476					.551					.528				
SE 3		.528					.551					-					-					-					-				
SE 4		.502					.458					.501					.445					.545					.497				
SE 5		.495					.455					.461					.413					.471					.426				
SE 6		.459					.420					.405					-					.545					.414				
SB 1			.788					-.808					.756					-.794					.791					-.842			
SB 2			.784					-.796					.771					-.803					.787					-.832			
SB 3			.626					-.626					.456					-.440					-					-			
SB 4			.571					-.548					.419					-					-					-			
SB 5			.527					-.511					-					-					-					-			
TD 1				.695					.734					.601					.636					.557					.587		
TD 2				.674					.683					.611					.622					.633					.652		
TD 3				.667					.641					.628					.607					.675					.682		
TD 4				.661					.679					.589					.607					.542					.558		
TD 5				.648					.626					.604					.581					.628					.617		
TD 6				.617					.576					.557					.430					.569					.514		
TD 7				.535					.476					.486					.420					.486					.426		
ES 1					.676					.657					.547					.529					.537					.518
ES 2					.656					.632					.610					.569					.653					.660
ES 3					.637					.621					.608					-					.622					.587
ES 4					.598					.596					-					.599					-					-

Factor	No. of items	Cronbach's alpha
1 - Interest and motivation	4	0.715
2 - Self-efficacy beliefs	6	0.651
3 - Self-regulated behaviors in teams	5	0.760
4 - Team dynamics	7	0.808
5 - External support	4	0.658

Table 3-7 Number of items and Cronbach's alpha for each factor

CHAPTER 4. RESULTS

4.1. SYSTEMATIC REVIEW (PAPER 1)

This paper adopted the "search-screen-appraise" method advocated by (Borrego et al., 2014). Seventy-seven relevant articles were deemed eligible after full-text analysis had been conducted. The review aimed to answer the following two research questions in Paper 1:

1) What are the characteristics of intercultural team collaboration that have been reported in engineering educational research in terms of formats, countries, level of collaboration, learning goals, evaluation methods and learning gains?

2) What challenges have engineering students encountered in intercultural team collaboration and what are their corresponding coping strategies?

First, a metadata analysis was carried out. This considered sources of publication, researchers' countries, the disciplines of study participants, research methods, numbers of participants, analytical theories or frameworks, and year of publication. The results indicate that most included studies were published in the journals covering the engineering, education, and technology fields. Only a few studies targeted intercultural engineering teams within journals of language or culture. Over 90% of the authors of the 77 included studies came from European, North American, or Asian countries. The authors of the remaining seven studies came from countries in the southern hemisphere. Fifty-three out of 77 studies reported students' disciplines, and 36 studies demonstrated collaboration and data collection across engineering disciplines or beyond them. However, only 16 studies discussed interdisciplinarity as a cultural variable and linked culture or intercultural engagement to the engineering disciplines of students. Only two studies produced results showing that differences between students of different disciplines were more important than differences between students of different nationalities (Guerra, 2017; Montgomery, 2009). The analysis indicated that PBL was the most frequently reported analytical theory; this finding theoretically supports our further investigation of intercultural team learning within a PBL context.

To answer the question of what characterizes intercultural team collaboration in engineering educational research, this review provides details about intercultural team formats, collaborating countries, levels of collaboration and preparation for teamwork, learning goals, evaluation methods, and learning gains. First, different structures and formats of collaboration are used; the most frequent are intercultural teams within/across an institution and globally distributed virtual teams (e.g., Downey et al., 2006). This international orientation reflects not only the need to create a dynamic and inclusive learning environment within universities, but also the increasing demand for

remote work arrangements (Anderson & Ramalingam, 2021; Rutkowski et al., 2008). Both these approaches enable engineering students to prepare for working in a globally interconnected society. Second, in most cases, engineering students work within small or medium size teams (less than eight members), which make it easier for students to make efficient decisions, organize frequent meetings, and increase individual involvement and empowerment. Third, although students collaborate at course, project, or program level, very few studies indicated how they prepare for intercultural teamwork. Most of the studies described student participation in cultural orientation courses, technical courses for virtual teams and language training courses (e.g. Andersen, 2004; Mehalik et al., 2008). Only five articles discussed informal team social activities or predeparture meetings before short-term study abroad (e.g., Ball et al., 2007; Wilson et al., 2019). Fourth, in terms of the learning goals that engineering students intend to achieve in their courses, projects or programs, the frequent use of multiple learning goals (combining both engineering disciplinary goals and intercultural learning goals) was reported. This shows that some engineering institutions now make an effort to equip their students with a broad range of skills and knowledge across different areas, and to promote students' transferable skills so that they can adapt to different roles and contexts, as what also stated in some prior literature such as Hou & McDowell, 2014 and O'Connell & Resuli, 2020. Fifth, several methods for evaluating students' intercultural team learning outcomes are reported in the literature, with students' self-reported assessment being the most common method. Although teachers' or faculty staff members' reflections and observations are considered necessary for student intercultural learning, they were reported the least frequently in the included studies. Sixth, learning gains are discussed and analyzed on the basis of the results of student, teacher, and researcher evaluations. Five aspects are thus included: cognitive development, affective development, competence improvement, behavioral adjustment, and increased interactions with wider contexts. The majority of studies reported an increase in the competence of engineering students, and also in their cognition and affection. However, very few studies documented students' actual actions in terms of intercultural practices, or their external interactions with wider socio-cultural settings (e.g., Ingram et al., 2013; Wilson et al., 2019).

Several challenges that engineering students have encountered in intercultural teamwork and their corresponding coping strategies were identified and categorized into three levels: individual, relational, and contextual. Individually, although students faced challenges in terms of language, psychology, and differences in prior background and experience, there is a general lack in the literature of descriptions and discussions of how students deal with the latter two challenges. The greatest number of challenges were reported at the relational level, which encompasses time management and planning, interaction and communication, technology for working in virtual teams, and teamwork and teambuilding. Only eight articles reported challenges relating to team members' relationships with other stakeholders such as supervisors, institutions, clients, or local communities (e.g., Ellzey et al., 2019;

Rutkowski et al., 2008). Intrapersonal problems and interpersonal challenges within teams were the most frequently reported challenges, indicating that institutions place a greater emphasis on intercultural collaborations within student teams than the teams' interactions with their wider socio-cultural settings.

To sum up, these findings provided me with a comprehensive understanding of how engineering students work in intercultural team settings and connected students' personal values with intercultural actions and environments. In this paper, a culture-as-construct approach was adopted to define culture as a fluid and dynamic process, with nationality serving as one of the variables explaining students' identities and intercultural teamwork performance (Handford et al., 2019). More discussion and analysis of how the authors of the included studies understand culture and specific relevant variables (e.g. disciplinary culture, ethnic culture, institutional culture, international experience and so on) is included. Additionally, it is important to explore whether these different variables have any hierarchy of relevance or importance when defining culture in the engineering education field. While analytical theories and frameworks were mentioned in Paper 1, they were not analyzed in depth. It is worth discussing how these determined the structure of this research and their views on theoretical perspective on intercultural teamwork. This study identifies a research gap with regard to students' cognitive and affective development, their actual engagement in intercultural learning, and their actual interactions with their situated surroundings. Engineering students should be encouraged to be proactive, which prompts my subsequent focus on their retro-perceptions of learner agency and what elements of agency development supporting them in an intercultural PBL context.

4.2. QUALITATIVE STUDY (PAPER 2)

This study used a narrative inquiry approach to answer the following two research questions in Paper 2:

1) How do engineering students perceive the development of their learner agency in an intercultural PBL environment?

2) What factors influence the development of engineering students' learner agency in an intercultural PBL environment?

Conceptualizing learner agency and intercultural learning allowed a framework of learner agency in an intercultural PBL environment to be illustrated and discussed in detail. Elements from the three-dimensional (interpersonal, behavioral, and environmental) conceptual framework was integrated with the themes and subthemes emerging from the inductive findings of the narrative inquiry.

The findings were analyzed on the basis of these three dimensions to answer the first research question, with 10 elements perceived as contributive to engineering students' development of learner agency. In the intrapersonal dimension, engineering students built self-efficacy beliefs, motivation, and professional identities as global engineers within an intercultural PBL context. Prior studies have also pointed out the importance of self-efficacy beliefs and motivation in this dimension (Chaaban et al., 2021; Du et al., 2022; Shin, 2018). In particular, these 11 engineering Masters students believed that PBL had improved their understanding of professional knowledge, as well as their confidence in teamwork, problem identification, the application of theory to practice, and the handling of more complex problems. By acquiring PBL experience during their Masters studies, some students felt that they had become more active and more engaged in their project work and team collaboration. Working in an intercultural team setting increased their belief in the importance of intercultural awareness, transferable skills, effective intercultural communications, language proficiency and appreciation for the views of members with different disciplinary and cultural backgrounds. After being immersed in a PBL learning context, some engineering students' motivations shifted from extrinsic to intrinsic. Specifically, there was an increase in their desire to self-initiate, determine and preserve their own learning, as well as in their interest in exploring problems from a global perspective. When asked what intercultural PBL experience did for them, six participants said, with some nuances, that it strengthened their sense of identity as global engineers. For instance, one local student and two international students stated that it helped them get ready to work in international workplaces as engineers in the future:

> "I think this [the international environment] helps me get to be a global engineer. If I want to be an international architectural engineer, I might need to work in other countries." (Karl)

> "By experiencing this PBL for the entire semester, I would say that is one of my goals, and would be nice to work globally in the future as an engineer." (Sofie)

> "I believe it [intercultural PBL] gives me experience and confidence of working with culturally different peers. It will influence my choice to work in a more international and inclusive company." (Ida)

In addition, when asked about their preferences with regard to working environments, two Danish students (Theo and Belle) stated their willingness to work with people from different countries in the future, even though they saw themselves working in local companies.

> "I would place myself in a small or local company. But working with international people in the future and just speaking English is totally fine for

me. Maybe I would prefer to work with them because there is always something to talk about [with them]." (Theo)

"Even though it is still difficult for me to speak English, working together with others [internationals] in the same company would be good and interesting." (Belle)

When asked to compare his experiences of engineering studies in Spain and Denmark, one international student (Erik) remarked that Denmark has a higher attrition rate among engineering students, and higher salaries for engineers. He further stated his wish to become an engineer in Denmark.

"If I got my Master's degree, this becomes a key for opening my door in Denmark. If I get this engineering Master's in such a university with high reputation in Denmark, I think I can work in here whatever I want." (Erik)

In the behavioral dimension, four elements were included: goal setting, plan making and project management, monitoring, and evaluation and reflection. First, although international PBL beginners initially encountered difficulties in setting up common learning goals, adapting to the different working styles of others, and scheduling time, they described a shift in their role from an observer of the other non-international groupmates to an active participant in co-organizing project progression. This shift resulted from effective and active communication, participatory leadership, and flexible task distribution. This is consistent with the findings of (Bergman et al., 2022), who reported that over time engineering students took active roles in formulating strategies to manage their projects and achieve better communication. Second, when interacting within an intercultural team, students reported confusion about roles in the team, language barriers, and differences in ways of thinking, working, and communicating, which have been identified as challenges in many prior studies (LaFave et al., 2015; Popov et al., 2022). Consequently, they employed various coping strategies, such as using different ways to communicate, visualizing work progress through project management tools, asking for clarification, taking a team role test, and so on. When reflecting on their project progression, these students initially depended largely on the supervisors' evaluation to keep track of their progress. It was found that they became more autonomous in their reflections on projects through both peer assessment and self-reflection at later stages.

In the environmental dimension, students perceived their development of learner agency as being influenced by trust building, team atmosphere and support from supervisors and institutions. In a culturally mixed team, despite the fact that trust is established according to the extent to which team members adhere to their team contract in the first year of their studies, some second-year Masters students decreased their reliance on the contract. Most students maintained a positive attitude toward the intercultural team atmosphere, but some international students experienced feelings

of distrust, ignorance and isolation when working in a group consisting exclusively of local students. International students received adequate support from their semester coordinators and project supervisors, which reflects a statement by Spencer-Oatey and Dauber (2021) that the role of faculty staff in intercultural learning is providing "guided learning and support in order to facilitate students' engagement, reflection and learning from these opportunities" (p.13). However, the students felt that their departments and institutions did not provide much support to help them adapt to an intercultural environment.

The results indicate that several factors are relevant to the development of agency in intercultural PBL contexts. The most influential of these factors were students' prior experiences of PBL and their level of advancement in the program. According to Du et al. (2022), students will see engagement in PBL activities as less important if they lack prior experience in PBL. By gaining PBL and intercultural experiences over time, engineering students shifted their role from observers to active participants in their learning activities. This was reflected in increased autonomy and learning gains among students, in terms of the aforementioned three dimensions. In addition, differences in communication styles, the cultures of Masters programs, and project group compositions were also regarded as influential. These factors create different contexts which help students be more aware of cultural differences, co-create group goals and co-manage projects.

However, the findings of this study could have been improved in several ways. First, the term "development" assumes that students all have the potential to develop agency but neglects situations in which passive approaches are adopted by students. Furthermore, this study explored elements contribute to learner agency development only through engineering students' retro-perspective self-reflection. The findings would be more convincing if development was examined before and after experiencing PBL in intercultural teamwork, with more rounds of interviews. This would help make clear whether students develop agency over time or not, as has been argued in Section 3.4.1.4. Despite being one of the elements within the intrapersonal dimension, students' sense of identity as global engineers is actually examined through the reflections of engineering students, whose intercultural PBL experience strengthened their beliefs about their ability to work as engineers in international companies or local companies with international colleagues. Thus, this element could also be categorized under self-efficacy beliefs.

4.3. QUANTITATIVE STUDY (PAPER 3)

The conceptual framework on learner agency in an intercultural PBL setting, and the contributive elements of learner agency development perceived by a small group of engineering students drawn from the narrative interview data in Paper 2, were used as

references when developing the quantitative instrument and categorical information for subsequent quantitative data analysis. This instrument is designed to explore a larger sample size of students' perceptions of elements of learner agency in intercultural PBL settings identified in Paper 2 that they consider crucial to their learner agency development. It anticipates that a more extensive study involving a larger number of participants will help establish a more in-depth understanding of learner agency in intercultural PBL settings.

This study began by conceptualizing learner agency and intercultural learning, and then discussing recent empirical quantitative studies that focus on these two concepts. However, none of these recent studies quantified learner agency development in an intercultural PBL team, nor did they explore interculturality in depth. Hence, to address this research gap, this study aimed to explore the following research question:

"What elements do engineering students consider important for supporting their development of learner agency in an intercultural PBL team?"

A three-dimensional conceptual framework (intrapersonal, behavioral, and environmental) adapted from our qualitative study described learner agency in an intercultural PBL team setting. The environmental dimension specified both intercultural settings within teams and external intercultural settings. This framework theoretically inspired our new survey instrument design. By analyzing construct validity (using EFA) and reliability (using Cronbach's alpha), five factors were then identified: Factor 1 - interest and motivation; Factor 2 - self-efficacy; Factor 3 - self-regulated behaviors in teams; Factor 4 - team dynamics; and Factor 5 - external support. Each of these five factors was assigned to one of the three dimensions in the conceptual framework. Factor 1 and factor 2 pertain to the intrapersonal dimension, factor 3 describes the elements in the behavioral dimension, and factors 4 and 5 explain the environmental dimension, respectively.

The results of the statistical analysis indicate that students generally gave positive responses to Factors 1, 2, 3, and 4, indicating that students perceived these four factors as supportive of their development of learner agency in an intercultural team setting. Although the mean score for Factor 5 was lower than the test value of 3.00, the one-sample t-test revealed that students considered it as having a neutral influence on their development of learner agency. Meanwhile, paired t-tests were performed to compare the means of different factors, as shown in Table 4-1. Significant differences were found between all ten pairs, which means that mean values between the two factors were basically comparable.

Pair	Factor	t	df	Sig. (2-tailed)
Pair 1	IM	10.478	618	<0.001
	SE			
Pair 2	IM	12.265	618	<0.001
	SB			
Pair 3	IM	3.939	618	<0.001
	TD			
Pair 4	IM	20.702	618	<0.001
	ES			
Pair 5	SE	3.218	618	0.0014
	SB			
Pair 6	SE	-6.695	618	<0.001
	TD			
Pair 7	SE	12.516	618	<0.001
	ES			
Pair 8	SB	-8.995	618	<0.001
	TD			
Pair 9	SB	8.65	618	<0.001
	ES			
Pair 10	TD	17.813	618	<0.001
	ES			

Table 4-1 Results of paired sample t-tests

As this is a newly developed instrument, analyzing which item showed the highest mean value under each factor not only provides a descriptive overview of the scale, but also enabled me to determine which items could be considered and refined in the future studies. The items that the students perceived as the most important for supporting agency development were: preparation for future work in a global context (in Factor 1), ability to work with people in different backgrounds (in Factor 2), regular checking of the team plan (in Factor 3), co-adjustment of the team plan (in Factor 4), and training activities held by university/faculty to teach strategies for working in an international setting (in Factor 5). Although most items were perceived by engineering students as important, items pertaining to supervisors' support, online resources, and other needed materials made limited perceived contributions to agency development. This result differs from the findings of Paper 2 and some other prior studies, which found teacher/supervisor support to be one of the main sources of support for learner agency (Du et al., 2022; Du & Naji, 2021; Jääskelä et al., 2017). One possible explanation could be that AAU's PBL model provides engineering students with an environment of self-directed and student-centered learning wherein students take ownership of the learning process, self-explore the learning contents, and depend less on their supervisors to help them solve problems (Dahl et al., 2016). The students' positive attitudes toward institutions found in the current study are also contrary to the findings of Paper 2, which showed that institutions did not provide much support for students. Hence, the item on institutional support (ES 3) shall be further refined and tested when new datasets are collected, so that comparisons can be made.

Several demographic variables were found to be relevant to engineering students' agency development, including gender, nationality, year of study and type of PBL learner. These results were measured using a t-test and an ANOVA test. In general, statistical differences were found significant for Factor 1 among all groups, indicating that students rely on internal sources, especially their motivation and interest, for agency development in intercultural teams. By comparing the mean scores for all factors that were considered significant in different groups, it was found that female students, international students, undergraduate students and PBL beginners gave higher scores than others in the same group, reporting that these factors had a higher level of importance. This result aligns with a prior study in which female engineering students were found to be more at ease with cultural differences and experienced better intercultural interactions than male students (Jesiek et al., 2012; Thompson & Jesiek, 2010).

CHAPTER 5. DISCUSSION AND CONCLUSION

5.1. META-REFLECTIONS

This PhD thesis investigates the development of learner agency among engineering students within intercultural PBL settings. Three research questions are proposed:

> RQ 1. What characteristics, challenges, and coping strategies of student intercultural team collaboration have been reported in engineering education research? (Paper 1)
>
> RQ 2. How do engineering students perceive their development of learner agency and what are the factors influencing its development in an intercultural PBL environment (Paper 2)
>
> RQ 3. What elements do engineering students consider important for supporting their development of learner agency in an intercultural PBL team? (Paper 3)

To briefly answer these three questions, engineering students' intercultural team collaboration has a variety of characteristics. They also face several challenges and take different coping strategies, which are summarized at the individual, relational and contextual level. In an intercultural PBL environment, engineering students perceived various elements and influential factors as contributive to develop their learner agency under three dimensions (intrapersonal, behavioral, and environmental) based on qualitative findings; and their internal motivation was perceived as the most important contributor to their learner agency development according to quantitative results. From these findings, several reflections are elaborated from theoretical and methodological perspectives. The limitations and future research areas are also discussed in this section.

5.1.1. REFLECTIONS AND LIMITATIONS ON THREE PAPERS

Despite the fact that the data used in this PhD thesis were collected through a linear and longitudinal process in three phases, our findings and reflections are linked to each other; this is visualized in Figure 5-1.

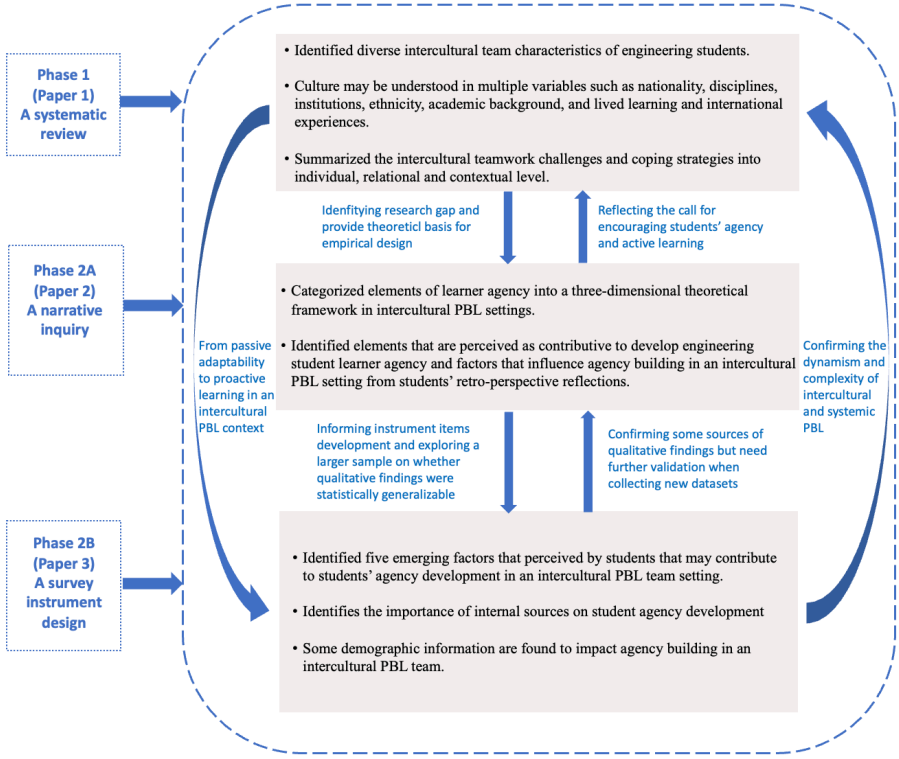

Figure 5-1 Summary of relationships between the phases of the study

Paper 1 provides a holistic picture of the characteristics and challenges of intercultural teamwork as experienced by engineering students, and the coping strategies suggested by prior studies. This study helped me realize that culture can be understood from a constructivist perspective, whereby it is not something inherent and static with certain beliefs, values, and behaviors, but a fluid and changing process in which individuals negotiate and co-construct meaning and interact with others or larger socio-cultural environments (Dervin, 2011; Handford et al., 2019). In this sense, engineering students' national culture only functions as one of the sources supporting their intercultural learning. It has been found that other sources such as students' disciplines, engineering institutions, and geographic regions, and their processes of interacting with others, contribute to shape their identity and their learning in intercultural environments. Prior studies have indicated that in addition to the aforementioned sources, variables such as gender, ethnicity, academic background, and prior international experience may also exert an influence (Bani-Hani et al., 2018; Guerra, 2017; Jesiek et al., 2012). Additionally, while the majority of included papers discussed the development of students' intercultural awareness and mindset, less attention has been paid to their actual engagement with intercultural teamwork and

interactions with their situated surroundings. As a prior empirical study has pointed out, despite engineering students being expected to develop intercultural competence only a small number engage in intercultural activities (Bergman et al., 2022). Therefore, engineering students should be encouraged to be proactive and develop their agency for intercultural learning. The conclusions of these prior studies led to my subsequent focus on exploring the contributive elements of learner agency development for students in an intercultural PBL context.

However, Paper 1 could be more critically analytical about the definition of culture in intercultural teamwork, and about how researchers understand culture in their studies. Although I assume that several variables might be relevant to students' intercultural teamwork, whether they have any hierarchy of relevance in terms of their influence on students' intercultural teamwork performance is a subject which requires further discussion. In addition, this study could take a more critical stance on how the included papers constructed and analyzed intercultural teamwork in terms of theoretical learning frameworks, as well as the ways in which these frameworks benefit future works on analyzing intercultural teamwork. Third, this study summarizes characteristics, challenges and coping strategies from student perspectives, but more detail could also be provided on the challenges that teachers/instructors/supervisors encounter in the process of facilitating students' intercultural teamwork and intercultural learning, and what coping strategies teachers can make use of.

By providing an overview on engineering students' learning in a general intercultural context, Paper 2 narrows down the research focus to learner agency and explores how do engineering students perceive their learner agency development and what factors influence the development. Firstly, a literature review was conducted on the conceptualization of learner agency and intercultural learning. As a result, an initial conceptual framework with multiple elements under intrapersonal-behavioral-environmental dimensions was proposed for describing what element is contributive to learner agency development. By carrying out a narrative inquiry for a small amount of engineering students (n=11), ten elements under three dimensions that perceived by students as contributive to their learner agency development. These elements were categorized as intrapersonal (self-efficacy beliefs, motivation for intercultural PBL and sense of identity as a global engineer), behavioral (goal setting, planning, monitoring, and reflecting), or environmental (trust building, team atmosphere and support from supervisors and institutions). Based on students' narratives, PBL beginners are not always able to perform in proactive and agentic ways at the beginning of their studies. This is also a challenge for experienced local students who are familiar with AAU PBL model and who are required to enact their agency in an intercultural context. On the other hand, this could be viewed as an opportunity for both sides to enact agency by re-negotiating the conditions of their study, collaborate to solve complex problems, and use sense-making and effective communication to develop strategies. In addition, experiences of PBL prior to Masters studies, the

academic year, and the cultures of different study programs or academic disciplines, group formation were shown to influence students' development of agency. This is consistent with a prior study which indicates that effective learners are able to exercise their agency by activating their prior learning experiences (Bown, 2009). It is also aligned with the findings of some articles which found that differences between students' academic disciplines are more prominent than differences between their nationalities (Guerra, 2017; Montgomery, 2009).

However, several issues could have been addressed in more detail in this study. First, when reflecting the ten contributive elements under three dimensions, students' sense of identity as global engineers could be further categorized into strengthening their self-belief in their capacity to work in intercultural companies or with international colleagues in the future. Second, this study assumes that an intercultural PBL environment develops students' agency, but neglects the fact that agency might not be developed by some engineering students. Since the participants only worked in an intercultural PBL team for one semester, more rounds of interviews could help me understand whether they actually develop agency or not by gathering evidence of different team experiences. Third, it is also critical that the evidence for engineering student's learner agency development presented in this study is based on retrospective reflections at different stages of the students' experiences, rather than on a rigorous examination of students' experiences before and after working in an intercultural PBL team. These three points have also been emphasized in previous sections. Fourth, this study only examines a small sample of students in a certain Master's program at AAU. It could be extended to include a broader scope of participants from more engineering programs and both Bachelor's and Master's students in different academic years. A quantitative study including more participants is thus needed in the final stage of my PhD journey to explore the bigger picture of whether any of our qualitative findings are statistically generalizable.

Paper 3 designed a new instrument to explore students' perceptions of what identified elements of learner agency in intercultural PBL team settings are more important at a larger scale. The initial conceptual framework devised in Paper 1 and the empirical qualitative findings presented in Paper 2 functioned as references when developing the items in Paper 3. Using EFA, five factors emerged: Factor 1 - interest and motivation; Factor 2 - self-efficacy; Factor 3 - self-regulated behaviors in teams; Factor 4 - team dynamics; and Factor 5 - external support. As a preliminary assumption, each of these underlying factors were assigned to one of the three dimensions in the conceptual framework established in Paper 2. Factors 1 and 2 pertain to the intrapersonal dimension, factor 3 describes the elements of the behavioral dimension, and factors 4 and 5 explain the environmental dimension. However, this assumption needs to be further confirmed when collecting new datasets in different PBL settings. The descriptive statistics indicate that engineering students perceive motivation and interest as the most important factors of all, further indicating a greater reliance on internal sources than external sources, and a greater emphasis on

personal autonomy when working in an intercultural PBL setting. Prior literature has also confirmed that engineering students emphasize the importance of motivation in PBL settings (Du et al., 2022; Shin, 2018). Although team dynamic was deemed essential for supporting the development of learner agency, of all the external resources mentioned only institutional support was recognized as helpful or beneficial. Students perceived the contribution of supervisor support, online resources, and other materials to the development of learner agency in an intercultural PBL context as being limited. One possible explanation for these differences is that different departments and supervisors may set different levels of requirements for their engineering students when preparing them for intercultural teamwork and collaboration (Ball et al., 2007; Mehalik et al., 2008).

Paper 3 is subject to several limitations. This study only applied EFA for factor analysis, and some other psychometric properties such as CFA could have been taken into consideration. However, due to the relatively limited sample for EFA, the purpose of this study and practical issues illustrated in Section 3.4.2.3, additional psychometric properties such as CFA could not be utilized to further validate the scale in this round. Notwithstanding these limitations, this study found that the Cronbach's alpha values for factors 2 and 5 were lower than 0.7, which prompted me to refine the items of these two factors to reach higher reliability in the future studies. The development of a new instrument is a long, arduous, and challenging process, which requires several rounds of data collection to validate the instrument. However, due to the limited time available to complete my PhD (three years), the data of Paper 3 were only collected in the context of a single university (i.e., AAU's PBL model), which may limit the generalizability of the results. It is therefore necessary to apply it, even after this three-year PhD, in multiple PBL contexts or universities and compare the results to confirm my findings from EFA. Third, the results are limited due to the low numbers of female and undergraduate students in the sample. Therefore, future research could test, measure, and compare students from PBL contexts with a particular focus on female students and undergraduates.

To summarize, the AAU intercultural PBL setting produces a supportive environment which allows engineering students to develop learner agency and effectively prepare to work professionally in a global context. The development of learner agency in intercultural PBL settings is a complex and dynamic process in which all the elements reciprocally interact with each other. It requires not only personal autonomy, but also self-regulated learning in a team-based environment, and individual and collective efforts to co-construct meanings within the wider socio-cultural context.

5.1.2. METHODOLOGICAL REFLECTIONS AND LIMITATIONS

Earlier studies explored student development of learner agency mainly on the basis multiple qualitative data sources or small participant samples, analyzed using narrative inquiry and ethnographic approaches (Mercer, 2011, 2012), Q methodology (Du et al., 2022), or focus groups and observation (Du & Naji, 2021). This PhD study first used a systematic review approach to produce an overview of engineering students' intercultural teamwork, followed by an exploratory sequential mixed method to investigate learner agency development in an intercultural PBL environment.

By screening, synthesizing, and appraising all relevant articles about engineering students' learning through intercultural teamwork, the systematic review enabled the authors to summarize and analyze the various characteristics of intercultural teams of engineering students, along with the challenges that the students encounter when working in intercultural teams. The results helped me form a comprehensive understanding of student learning experiences within intercultural team settings and inspired the further study of these environments.

However, the literature search was restricted to five databases and inclusion criteria limited the study to peer-reviewed journal articles published in English between 2000 and 2022. There was a lack of additional information from conference papers, non-English journals, non-academic reports and articles, contributive theses and dissertations, grey literature, reports, and so on. The search process may also have excluded a number of relevant non-indexed journal articles, and articles which were not available electronically or were not easily accessible. In addition, some journal articles pertaining to the characteristics of intercultural teamwork may have been left out during this screening process due to the use of titles and keywords which only imply that they relate to intercultural teamwork. This limitation could be reduced through another round of reference list checks for all articles included following the database search. Some alternative snowball searching methods, such as key journal or author searching, could also have been used (Booth et al., 2016). Finally, researchers' bias could be further reduced in the title-keywords-abstract screening process by inviting more researchers to double check whether relevant article have been mistakenly removed.

The exploratory sequential mixed method in this study began with a narrative inquiry in a small scale and followed by the application of a new survey instrument to a larger sample (Creswell, 2009). Although this method allows me to comprehensively understand learner agency and maximize the benefits of both qualitative and quantitative methods, Creswell (2012) stated the disadvantages of this method as "requiring extensive data collection as well as the time required for this" (p.544).

The qualitative study (Paper 2) reports that engineering students perceive their learner agency development by identifying several elements as contributive. However, this is investigated on the basis of students' retrospective perceptions, rather than keeping track of them at different stages of their PBL study. Therefore, this study could have benefited by conducting interviews across different timelines to provide insights into development over time and the temporality of narratives from the same participants on learner agency development. Furthermore, I analyzed narrative data using an integrated approach combining deductive technique, which is theory-driven and inductive technique using a bottom-up thematic approach. This has been criticized by some researchers as reductionist and for potentially causing the meanings of the stories to be lost (Floyd, 2012; Lichtman, 2023). However, due to information redundancy, it was impossible for me to conduct a more holistic analysis of each participant (n=11), which is the alternative viable approach in narrative analysis (Floyd, 2012). Moreover, although "supplement" and member checking methods were applied during the auditing process, the trustworthiness of Paper 2 could also be enhanced by performing both inter-coder reliability and intra-coder reliability tests, as stated in Section 3.4.1.4.

The quantitative study used in Paper 3 has some limitations. First, the Cronbach's alpha value of two factors (factor 2, self-efficacy; and factor 5, external support) was only moderate ($\alpha < 0.70$). Based on prior literature, although values between 0.65 and 0.70 are seen as acceptable by prior literature, values reaching 0.70 and above are seen as good (DeVellis, 2012; Taber, 2018). To increase reliability, it is suggested that the result of this study should be further tested and some items in these two factors shall be meticulously refined and evaluated in the future studies. Second, it was found that the varimax rotation method is more appropriate for uncorrelated factors, while direct oblimin is more appropriate for correlated factors (Howard, 2016). Varimax rotation was randomly chosen in Paper 3 because when performing both varimax rotation and direct oblimin, no real difference was observed in terms of the items pertaining to each factor (see Table 3-6). In this sense, different rotation methods could have been more rigorously chosen and evaluated.

5.1.3. REFLECTIONS ON MY POSITIONALITY IN THIS STUDY

The task-based PBL approach that I utilized to teach Chinese language and culture facilitated my understanding of "culture" and "interculturality" as a fluid and dynamic process, influenced my choice of intercultural PBL as a research topic, and enhanced my intercultural competence when relating to individuals from diverse backgrounds. Furthermore, my status as an international PhD student working and living in Denmark supported my interpretation of the pilot study conducted in the first year of my PhD. I interviewed four Chinese engineering Master's students in a pre- and post-timeline for an entire year. The experiences and challenges they encountered in a

Danish PBL setting at the beginning of their studies recalled my own reflections on some similar issues that I have encountered relating to language barriers, sense of belonging, social integration, and so on. Over time, these students were not merely passively influenced by their situated environment and did not only adapt to it, but were able to make choices and contribute to their environment. They shifted from observing others or passively receiving information to actively co-constructing their learning and engaging with activities. On the other hand, international PBL beginners do not always have access to an intercultural PBL setting in which they can be proactive immediately. This also posed challenges for their Danish teammates, who were familiar with AAU PBL model and more capable of learner agency. These findings thus shifted my research focus from exploring intercultural PBL as an adaptation, to opportunities to develop agency among both international and Danish students.

My international identity, my review work in Paper 1, and the pilot study allowed me to activate my prior experiences when engaging with the narratives of eleven engineering students and helped me interpret and understand their stories as a researcher in Paper 2. It further partly influenced my decisions on which items were relevant and should be included when designing a new instrument in Paper 3. As an international student myself, I am clearly aware of the challenges of integration as an international in an intercultural environment, but I may lack a deeper understanding on how Danish students experience intercultural encounters and to what extent they are interested in engaging in intercultural teamwork within their country of origin. Furthermore, my prior academic background in education during my Master's degree program only supports my interpretations of findings from the pedagogical perspective. Nevertheless, I am also aware that I do not have an engineering background or have not been trained in engineering programs, which may limit my understanding of certain technical subjects, some fundamental concepts, and the role of interculturality or intercultural learning in the engineering field.

In retrospect, my PhD journey in the past three years has also been my own learner agency development process. While facing challenges in my research, uncertainty and insecurity, loneliness and isolation during the COVID-19 pandemic, and heavy work-loads, this journey developed my self-efficacy on my belief in my ability to deal with various difficulties, my confidence and motivation when working in an intercultural academic environment, my self-management abilities in terms of structuring my time and tasks, and my self-reflections on what could be improved.

5.2. CONTRIBUTIONS

This study contributes to the literature by systematically reviewing relevant journal articles from 2000 to 2022 to present a holistic picture of intercultural teamwork for higher engineering students over the past two decades. The systematic review article deepens insights into the definition of culture, types of team formats, the context of intercultural collaboration, ways of preparing engineering students for intercultural teamwork, methods for evaluating student learning outcomes, student learning gains, the challenges encountered in intercultural team experiences, and coping strategies to deal with these challenges.

This study also contributes a three-dimensional conceptual framework for demonstrating the elements which are perceived by engineering students as supportive and helpful to develop learner agency in an intercultural PBL setting. Based on the review of literature relating to learner agency and intercultural learning among students, various elements were identified in three dimensions, namely, intrapersonal, behavioral, and environmental. This framework not only provided this study with a conceptual foundation and guided its direction and empirical research design, but also provides a platform which researchers can use to refine their theories and develop new theoretical perspectives on this topic.

Methodologically, this study makes contributions by using sequential mixed method to enhance both the breadth and depth of the research findings. This study is exploratory in nature; it explored views on engineering students of their learner agency development by identifying different contributive elements in an intercultural PBL setting, and on what identified elements are more important for learner agency development. On one hand, the narrative inquiry method helped to generate relevant elements and meanings around students' agency development based on subjective viewpoints. These elements inspired the subsequent phase of designing new items for the survey instrument. On the other hand, the quantitative study explored the subject using a larger sample. Five factors were identified, and intrinsic motivation and interest were determined to be the most important factors for learner agency development.

5.3. PEDAGOGICAL IMPLICATIONS

The pedagogical and practical implications of our findings for engineering students, teachers and educators, and institutions are presented below.

FOR STUDENTS

First, five key categories were identified in Paper 1 to describe student learning gains in intercultural teamwork. Among these categories, most studies have reported students' cognitive, affective and competence development. However, only a few studies have revealed students' actual behavioral changes and their effective interactions with external socio-cultural settings. This gap between students' cognitive and affective development and their actual process of intercultural practice and interaction highlights the significance of learner agency, and the necessity of encouraging students to be more proactive during intercultural teamwork by taking the appropriate actions to resolve complex, real-world problems in a collaborative manner, making independent choices, and reflecting on the intercultural learning process.

Second, the challenges that engineering students encounter when working in an intercultural PBL team setting are reported at three levels: individual, relational, and contextual. The corresponding coping strategies are also presented; these allow students to address problems relating to language, time management and planning, communication and interaction, technology, team building and atmosphere, and relationships between other project stakeholders such as institutions, supervisors, local communities, and clients. However, the included studies do not specify how engineering students can overcome psychological issues and members with different backgrounds and levels of experience of working in an intercultural team. It is observed in Paper 2 that an open and inclusive team atmosphere would help address students' psychological problems; this requires every team member to foster open and transparent communication, embrace diversity, recognize the strengths and weaknesses of each team member, establish shared learning goals, build trust and respect, and so on. Although it is still hard to address an imbalance of experience levels in a team, several articles have pointed out that students' learning on professionalism, technologies, cultures, and collaboration improves over time (Popov et al., 2022; Vogel et al., 2001).

Third, the development of self-awareness when building learner agency will enable engineering students to proactively link their interests and intentions to decision-making, and thus to develop more appropriate learning strategies. Due to its complexity and dynamism, agency is also in high demand in intercultural PBL settings, as it helps students interact with others and positively influence – or be positively influenced by – the environment they are situated in.

FOR TEACHERS AND EDUCATORS

First, Paper 1 shows that the majority of studies have limited their understanding of culture to one's nationality, geographic region, or institutions. Few studies have defined culture at an interdisciplinary or multidisciplinary level, and there is a general lack of discussion linking culture to one's ethnicity. It is therefore proposed that engineering teachers and educators should consider the inclusion of students with

diverse backgrounds not only in terms of nationality, but also in terms of different disciplines, ethnicities, institutions, or levels of actual learning and international experience.

Second, too few studies have been conducted on how engineering students prepare for their intercultural teamwork, and a very limited number of studies have adopted theories related to culture as their analytical framework. Consequently, it is suggested that engineering instructors or faculty staff should design more formal courses, training programs and informal activities to support more effective intercultural teamwork among their students. Engineering students will benefit from adapting to culturally different team contexts at an early stage of their collaborative activities (Wilson et al., 2019). Furthermore, at this preparation stage, it is also necessary for teachers to introduce and highlight the interactive, dynamic, and complex characteristics of culture to help engineering students form a deeper understanding of intercultural team collaboration from theoretical perspectives.

Third, when implementing PBL and designing curricula, engineering staff and educators should be more sensitive to cultural diversity and the needs and experiences of certain groups, such as PBL beginners, female students, international students, and undergraduates. They should provide tailor-made physical and online resources to support the development of student agency in intercultural PBL settings.

FOR INSTITUTIONS

First, to address the psychological challenges that engineering students face in intercultural teamwork (as mentioned in Paper 1), engineering institutions should develop on-campus counseling centers for students who struggle to adapt to an unfamiliar intercultural situation. Additionally, they should provide students with structured and relevant lectures to prepare them for intercultural teamwork, and give advice and guidance to local students so that they understand the cultures of their international counterparts.

Second, when addressing the challenges of teams' relationships with other stakeholders, most studies included in Paper 1 focused on the student-instructor and student-institution relationships. In the future, ways of establishing relationships with other stakeholders (such as international clients, international companies, and local communities) should be investigated. It is recommended that universities and other institutions provide students with basic information about collaborating companies and the rules of local communities before collaboration begins. Furthermore, students will also benefit from site visits to institutions, communities and companies, and from face-to-face interactions with their staff (Gnanapragasam et al., 2015).

Third, it is suggested that institutions and universities provide supportive resources and on-campus activities for engineering students to encourage them to embrace

diversity, increase their awareness of other cultures, and enhance the development of learner agency in intercultural PBL environments.

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APPENDICES

Appendix A. Narrative Interview Protocol

Topic	**Exploring Engineering Students' Agency in an Intercultural PBL Environment**	
Participant		
Time		
Duration		
Place		
Type	Individual interview	
Form	☐ Online	☐ Face-to-face
Language	☐ English	☐ Chinese

Introduction

Dear XX, my name is Dan, and I am currently a PhD student at Aalborg University. My research focus is mainly on intercultural PBL in engineering education, and I will be conducting this interview today. The goal of this study is to explore engineering students' opinions on their own learner agency development in an intercultural PBL environment. Learner agency describes one's ability to build internal motivation and interest, set up goals, make choices, take actions, and reflect upon these choices, interact with an intercultural environment and so on. It is used an umbrella term for me to comprehensively gather your own experience of working in an intercultural PBL environment. You have been selected to talk with me because you have worked in an intercultural team for at least one semester and your own experience will contribute to this study.

This interview will be planned to last approximately an hour. To facilitate notetaking and analysis, I would like to audio record our conversations. Will you allow me to record it? All information will be held confidentially and only researchers working on this study will have access to this conversation for data analysis purposes. Your participation is voluntary, you may stop at any time if you feel uncomfortable. Are you ready to share your own experience with me?

Interview questions

Demographic Questions		
Could you please introduce yourself? (Country of origin, semester, program, department) Did you have PBL experience before your Master's program? Do you have experience of working with people from different countries?		
Main questions		
Dimensions	**General questions**	**Probing questions**
Intrapersonal	1.How do you understand PBL? (What does PBL mean to you?) 2. How do you feel about working with people from different countries/backgrounds on the project?	**Self-efficacy beliefs** • How do you believe your intercultural PBL experience affects you and your future? **Prior experience** • How have you previously experienced PBL? • How did that influence your current PBL team project work? **Motivation** • Based on your experience, what contributed to your motivation to learn in an intercultural environment at AAU? **Interest** • How does the current PBL project and the team interest you? • Are you interested in working in an intercultural team? If so, could you please elaborate more on your interest?
Behavioral	3. Could you please tell me about your project?	**Goal setting** • Do you have any personal goals and common learning goals with your team? Could you elaborate on this? **Plan making** • How do you make plans to manage your project? **Monitoring** • What challenges that you have encountered when working in an intercultural team? • Have you encountered any unexpected experiences? If so, could you please elaborate more on this? • How do you cope with these challenges? **Self-reflecting** • How did you self-evaluate your project work within your team? How do you encourage each other to self-reflect?
Environmental	4. Could you please share your story of how you work in an intercultural team? 5. What support did you receive to work in an intercultural team? and what did you do to contribute to the teamwork overall?	**Team interaction** • What do you feel or think about the atmosphere in your team? • What do you do within the team to build trust with each other? • Have you experienced any disagreements or conflicts with your teammates? If so, how did you cope with that and reach consensus? • How do you communicate with your teammates? • What did you do to achieve efficient communication? • What team roles have you played in your team? **External support** • Did you get sufficient support from your supervisors? If so, what support that you get? • What other support did you receive or seek to make the intercultural team function?
Concluding questions		
Is there anything around this topic that we have not yet discussed, but which you think it important for me to know?		

Appendix B. Survey Instrument

Dear participants,

You are kindly invited to participate in this survey which aims to explore your opinions regarding which relevant aspects have helped you to collaborate in an international PBL team, based on your recent experience.

This study is ethically approved by AAU and students' participation is voluntarily to participate in this survey. The demographic information will keep anonymous and solely for analyzing the differences of groups of students' opinions. All the data collection will be strictly followed the rules of Aalborg University, General Data Protection Regulation (GDPR) and the Danish Data Protection Agency. The data will be safely kept in AAU and will not be shared to the third party.

I consent my participation in this above-mentioned study: _____
(Your signature please)

Part 1 Demographic information

Gender
(1) ❍ Male
(2) ❍ Female
(3) ❍ Other
(4) ❍ Prefer not to say

Nationality:

_____

Age
(1) ❍ Under 18
(2) ❍ 18-20
(3) ❍ 21-23
(4) ❍ 24-26
(5) ❍ 27-30
(6) ❍ Above 30

Academic year
(1) ❍ First-year bachelor
(2) ❍ Second-year bachelor
(3) ❍ Third-year bachelor

(4) ❍ First-year master
(5) ❍ Second-year master
(6) ❍ Graduated

How long have you been studying in Aalborg University?
(1) ❍ Below 3 months
(2) ❍ 3 months - below 6 months
(3) ❍ 6 months - below 1 year
(4) ❍ 1 year
(5) ❍ 2 years
(6) ❍ 3 years
(7) ❍ 4 years
(8) ❍ 5 years
(9) ❍ more than 5 years

Your study program
(1) ❍ Architecture
(2) ❍ Biotechnology
(3) ❍ Bioengineering
(4) ❍ Chemical engineering
(5) ❍ Civil engineering
(6) ❍ Electronic engineering
(7) ❍ Energy Engineering
(8) ❍ Environmental engineering
(9) ❍ Entrepreneurial Engineering
(10) ❍ Industrial Design
(11) ❍ Mechanical engineering
(12) ❍ Software and computer engineering
(13) ❍ Other (Please state which other):

Part 2. Survey

The survey includes **31 items** in total.
Based on your recent experience in an international team project, to what extent have the following aspects helped you work in an international PBL team environment?
Please rate the extent from 1 (Not at all helpful or not relevant) to 5 (Extremely helpful).

	1	2	3	4	5
1. Working in an international team interests me.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
2. I have prior experience of working in an international team.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
3. I have knowledge about my team members' background at the project start.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
4. I am capable of working with people from different backgrounds.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
5. I welcome the diversity inherent in working in an international team.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
6. I know what it takes to work in an international team.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
7. I am confident in my ability to overcome challenges in my international team.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
8. I am able to take initiatives throughout the process of working on the project with my international team.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
9. I believe my international team experience could prepare me for future work in a global context.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
10. In my international team, I am motivated to explore problems in a global context.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
11. My international team is formed by common interests in the project topic.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
12. In my international team, we set up common learning goals at the project start.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
13. We make plans according to our learning goals in my international team.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
14. We regularly check up on the team plans to ensure they have been followed.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
15. We adopt time management strategies to organize projects.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
16. We meet regularly to work together on the project.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
17. We adjust our plans according to the project process.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
18. In case of unexpected issues, we meet together immediately to discuss solutions.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
19. My team encourages diverse individual opinions in our project.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
20. We work on project tasks which are distributed by individual strengths.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
21. We take turns to serve as team leaders.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
22. We support each other so no one lags behind.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
23. We provide constructive feedback to each other.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
24. My team encourages each member to speak out.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
25.My team makes efforts to constructively handle team conflicts.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
26. We are provided needed resources (e.g. materials, facilities) for our international project teamwork to function from our study program.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
27. We are guided by our project supervisor regarding how to work in an international team.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
28.We are offered training activities organized by the university/faculty on how to work in an international team.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
29.We make efforts to improve our communication skills in an international team.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
30. We self-evaluate our project process according to our learning goals.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍
31. We use online resources (e.g. Youtube, online courses) to learn more about how to work in an international setting.	(1) ❍	(2) ❍	(3) ❍	(4) ❍	(5) ❍

Part 3. Open-ended questions

1. Based on your choices indicated above, please explain why some aspects have helped you collaborate more in an international PBL team?

2. Based on your choices indicated above, please explain why some aspects have helped you collaborate less in an international PBL team?

3. What are some other aspects which helped you to work in an international PBL team that are not included in this survey? Please list and elaborate on these aspects.

Thank you for your participation. Please write any additional comments below.

Papers

Paper 1

A Systematic Review of Engineering Students in Intercultural Teamwork: Characteristics, Challenges and Coping Strategies

Dan Jiang, Bettina Dahl and Xiangyun Du

This paper is submitted to:

education sciences

MDPI

Review

A Systematic Review of Engineering Students in Intercultural Teamwork: Characteristics, Challenges, and Coping Strategies

Dan Jiang *, Bettina Dahl and Xiangyun Du

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Abstract: In response to the challenges posed by globalization and internationalization, engineering education programs are increasingly focused on knowledge, technologies, and competence that meet global needs. Against this backdrop, higher engineering students are often encouraged to collaborate in teams with others from diverse, cultural, and disciplinary backgrounds, for the purpose of preparing them to accommodate change and innovation across international working contexts. Within a growing number of intercultural systematic and meta-analysis reviews in engineering education, little attention has been paid to intercultural team characteristics, and even less has been given to the challenges of intercultural teamwork and the relevant coping strategies. Using a systematic approach, this paper reviewed 77 journal articles to identify the intercultural team characteristics of engineering students based on team formats, level of collaboration, learning goals, evaluation methods, and learning gains. Through the process of intercultural collaboration, several challenges and corresponding coping strategies were reported at the individual, relational, and contextual levels. Recommendations for future practice for engineering educators and programs faculties, and future research directions for engineering educational researchers, are proposed in order to support engineering students' intercultural team learning.

Keywords: challenges of international teamwork; coping strategies for intercultural teamwork; engineering education; intercultural team collaboration; systematic review

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1. Introduction

Teamwork is the predominant mode of professional practice in engineering, and engineering students nowadays are often required to actively participate in team projects or tasks and collectively address disciplinary, process-related, and complex problems [1]. An effective and well-functioning collaborative learning environment supports students' agency, sense-making [2], self-regulated learning [3], persistence, motivation [4], achievement, and skill acquisition [5]. In recent decades, several systematic and meta-analysis reviews have focused on engineering team issues, presenting a summary of evidence on topics such as the main effects of personality traits on team performance, team effectiveness, learning outcomes, and team competence development [1,6,7].

As global challenges become more complex and universities become more international, engineering students must focus on the knowledge, technologies, and competences that not only to define their own field of expertise, but are also essential to meet global needs and work with others from diverse backgrounds [8,9]. To meet these requirements, many institutions now deploy international project teams to prepare their students for accommodating change and innovation in future intercultural and international workplaces [10].

In order to systematically analyze intercultural teamwork, it is necessary to understand the notion of culture first. Handford et al. [11] framed culture as both a given and as a construct. The culture-as-given approach understands culture as predefined groups based

on nationality, and emphasizes the differences between other (national) cultures [11,12]. However, this approach has widely received criticism for being overly simplified, due to the limitations of its focus on nationality. The culture-as-construct approach regards culture as something "liquid" in which subjectivity, knowledge, and society are all dynamic and context-bound [13]. They interact with and influence each other and co-construct meanings regardless of national frontiers, and have blurred boundaries [14]. Therefore, an intercultural team describes a group of individuals from different backgrounds interacting in order to complete assigned, interdependent tasks, and to share responsibility for the final results [15]. In addition, it has been recognized as a collective entity, with team members interacting with other small groups or even larger socio-cultural settings [16].

Prior studies indicate that through intercultural team collaboration, students benefit from increased self-awareness and sensitivity [17], reduction of prejudices and stereotypes [18], and the development of new ideas, learning practices, and interaction skills [19]. However, challenges experienced by students in intercultural teamwork might constrain their learning and cause negative outcomes. An increasing number of articles have revealed that engineering students encounter challenges in communication and collaboration such as language barriers [20], a lack of interpersonal relations [21], and different ways of working and thinking [22], indicating that it is therefore necessary to summarize these intercultural team challenges from previous research articles in a more comprehensive manner. Furthermore, the coping strategies used to address these challenges must also be investigated to provide engineering students, engineering educators, and educational institutions with practical implications and recommendations.

Given the increasing focus on internationalization and teamwork in engineering education, it is therefore necessary to establish a broader understanding of the nature of intercultural teams. Despite the fact that a great number of studies have reported student teamwork in an intercultural setting, no comprehensive overview of this topic has been formulated as of yet. This research gap inspired us to generate deeper insights into the current characteristics of intercultural teams, as well as the challenges and coping strategies documented in the empirical engineering education research. In addition, it is hoped that this systematic review will contribute to our knowledge on the definition of culture, the context of intercultural collaboration, ways of preparing engineering students for working in intercultural teams, and their learning gains from intercultural team experiences. Finally, this paper will expand both the educators' and institutions' understanding of how engineering students' teamwork can be evaluated, and which team learning goals should be set. Therefore, this study aims to address the following research questions:

(1) What are the characteristics of intercultural team collaboration that have been reported in engineering educational research in terms of the formats, countries, level of collaboration, learning goals, evaluation methods and learning outcomes?
(2) What challenges have engineering students encountered in intercultural team collaboration, and what are their corresponding coping strategies?

2. Methodology

This study used a systematic review approach, which is defined as "a systematic, transparent means for gathering, synthesizing, and appraising the findings of studies on a particular topic or question. The aim is to minimize the bias associated with single studies and non-systematic reviews." [23] (p. 1).This approach allowed our study to make important contributions not only by presenting a comprehensive and explicit summary of the available evidence on our topic of intercultural team collaboration among engineering students, but also by using a rigorous and scientific approach to analyze the relevant works. To this end, a three-stage process was implemented, which was as follows: (1) planning the review; (2) conducting the review; and (3) reporting and dissemination [24,25]. Each stage will be elaborated in the following sections.

2.1. Stage 1. Planning the Review

2.1.1. Scoping, Search Terms, and Documentation Sources

As suggested by Booth et al. [25], this study began with an informal scoping search and review in September 2022, which served as a "trial run" for the systematic review in the next round. The scoping search and review enabled us to become familiar with the topic of international team effectiveness for engineering students, determine the research questions, refine the search strings, identify the relevant databases, examine the range of the literature, and develop an appropriate search strategy. In October 2022, the initial keywords were reviewed and revised by three librarians who had rich experience on database search and literature reviews. Table 1 shows the refined search strings.

Table 1. Keyword search string.

BLOCK	KEYWORDS
Block 1	Inter- OR cross- OR trans- OR multi-
AND	
Block 2	Cultur * OR nation *
AND	
Block 3	Team OR group OR collaboration OR cooperation
AND	
Block 4	Higher education OR HE OR universit *
AND	
Block 5	Engineering

* Truncation to broaden the search.

To ensure that the relevant literature was retrieved, five online databases, representative of engineering education, were consulted in October 2022: (1) Web of Science; (2) Scopus; (3) EBSCO; (4) ERIC (via ProQuest); and (5) Engineering Village. The key factors for selecting these databases were their extensive resources on journal articles, conference papers, and other documents, and their diverse coverage of engineering practice, research, projects, and concepts [26].

2.1.2. Inclusion and Exclusion Criteria

The search was limited to peer-reviewed journal articles in English to ensure the quality of the sources to be utilized and a manageable number of papers for analysis. A previous systematic review on intercultural learning in engineering education investigated the conceptualization of culture from 2000–2015 [11]. For this study, the timeframe was thus set from 2000 to 2022, which not only provides an updated overview of current intercultural studies, but also lays the groundwork for investigating intercultural team environments since the early 2000s. Furthermore, our informal scoping review found that relevant papers regarding this topic have proliferated since the 2000s. In order to focus on the empirical evidence on the students' intercultural team performance and challenges, conceptual and theoretical studies were excluded. The results of the scoping review indicated that while several prior systematic reviews and meta-analyses provided inspiration and a starting point, they do not directly address the focus of the current study. Therefore, while they were not analyzed, they were utilized for additional snowball searching, as the context for this study must be conducted within higher education in engineering. Full inclusion and exclusion criteria are presented in Table 2.

Table 2. Inclusion and exclusion criteria.

Criteria	Inclusion	Exclusion
Publication year	2000–2022	
Language	English	Not written in English
Type of manuscript	Journal articles	Conference papers, book chapters, dissertations, proposals, and reports
Type of publication	Research papers, project papers, and introduction of practice	Conceptual papers, systematic reviews, etc.
Topic	Intercultural team collaboration of engineering students	Students' international mobility, international co-authorship and research cooperation, international teachers' collaboration, introduction of the study abroad program, etc.
Context	Engineering education	Medicine, nursing, mathematics, and science
	Higher education	K-12 education, vocational education, and continuing education

2.2. Stage 2. Conducting the Review

2.2.1. Selection of Studies

The filtering process adopted the search-screen-appraise method recommended by Borrego et al. [26] in engineering education, in which studies are filtered based on titles and abstracts, and subsequently appraised for inclusion based on full-text analysis. Figure 1 illustrates the filtering process. In order to keep the results manageable, the review was initially limited to title, abstract, and keywords or topics retrieved from the five databases. The initial search yielded 769 articles. After removing 46 duplicates, a total of 723 articles were sorted for the further screening.

The first phase of screening reduced the number to 235 studies. Studies with irrelevant titles and keywords were removed, as were systematic reviews and conceptual papers. Following the process of abstract screening, the sample was further narrowed down to 95 articles. A total of 140 articles were excluded due to their focus on K-12 education, vocational education, continuing education, other higher education stakeholders (e.g., staff, teachers, institutions, or administration), or covering other fields (e.g., medicine, science, or mathematics). The selection process was repeated twice to ensure that any relevant publications had not been mistakenly removed. Through full-text screening, a total of 62 studies were selected for further open-coding analysis. The full-text screening process filtered out 33 studies due to their focus on the following: (1) international co-authorship among researchers; (2) collaboration among different institutions across countries; or (3) students' international mobility without emphasis on their team performance. As electronic searching may miss significant published studies, where the level of indexing is limited due to errors, inaccuracy, or concepts lacking appropriate subject headings [25], we identified further sources by manually examining the reference lists of these 62 studies and relevant systematic reviews. A total of 15 additional relevant non-indexed journal articles, such as Bani-Hani et al.'s [22] study published in the Journal of Problem-Based Learning in Higher Education, were found and subsequently included in this review. As a result, the final number of selected articles for our review was 77.

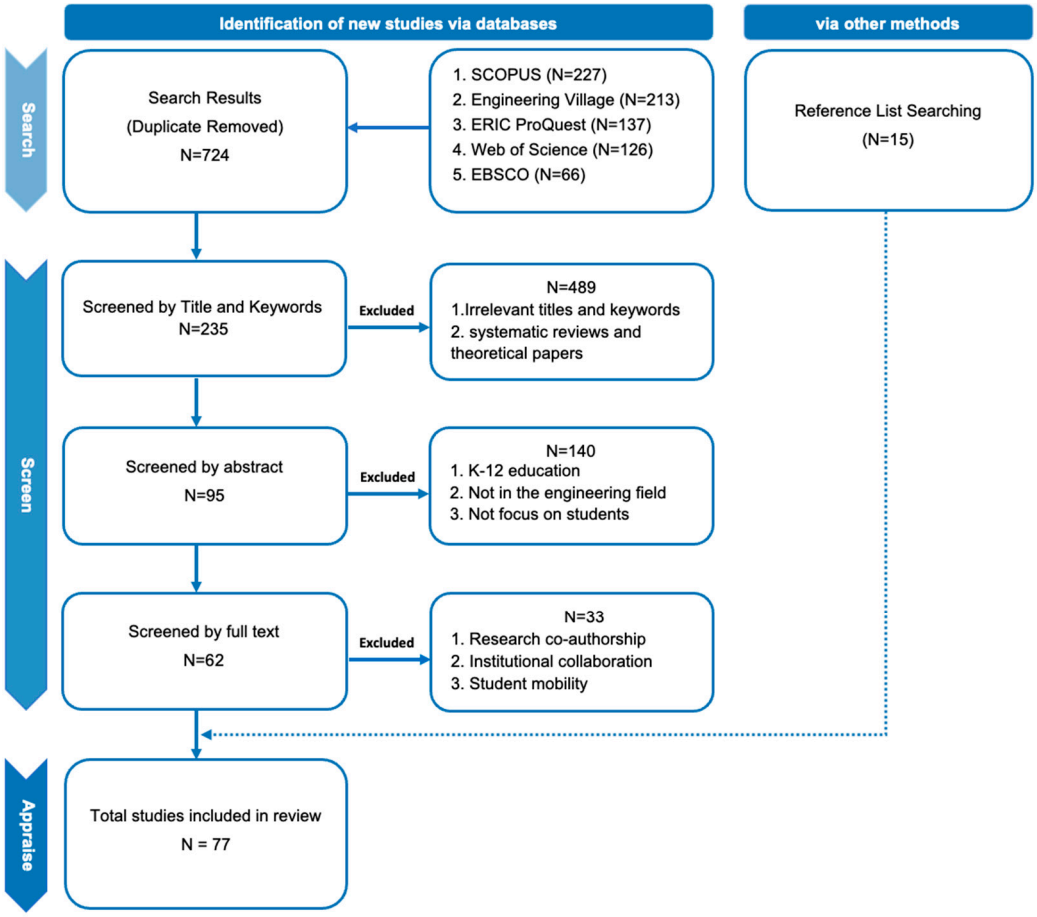

Figure 1. A flowchart of the filtering process.

2.2.2. Tracking and Analysis

In accordance with the content analysis process described by Borrego et al. [26], our analysis was carried out mainly using an integrated approach including both an inductive and a deductive approach. The initial codebook was developed and revised through two rounds of debriefing sessions among the authors; codes included themes such as basic information (journal names, type of collaboration, year, students' disciplines, and countries), research design, group formats, team size, group activities, learning goals, learning outcomes, challenges, and coping strategies. After the codes were decided upon, open coding was subsequently conducted. In order to minimize the researchers' bias and increase the validity of the coding process, all selected papers were read multiple times, and the coding process was led by the first author and triangulated by two experienced educational researchers in the research group. To enhance inter-coder reliability, all open codes from five articles were compiled into an assessment form and reviewed by one graduate student who is experienced in qualitative research but not familiar with this specific project. Consequently, 213 out of 247 codes were agreed upon, resulting in an acceptance rate of over 86%. As the final step in this auditing process, discrepancies between the results were discussed again within the research group, and the codes were revised accordingly.

2.3. Stage 3. Reporting the Metadata Analysis

In order to describe these 77 studies on engineering students' engagement in intercultural teams, the metadata were analyzed and categorized based on: (1) the publication source; (2) researchers' countries; (3) subjects of study participants; (4) research methods and number of participants; (5) analytical theories or framework; and (6) the year of publication.

Sources of publication. Approximately one-quarter of papers (n = 20) were published in the International Journal of Engineering Education, followed by the European Journal of Engineering Education (n = 9); Journal of Professional Issues in Engineering Education and Practice (n = 4); Australasian Journal of Engineering Education (n = 2); IEEE Transactions on Education (n = 2); and IEEE Transactions on Professional Communication (n = 2). Each of the remaining 38 articles was published from a different journal within the fields of engineering (e.g., Journal of Biomechanical Engineering); language and culture (e.g., The Modern Language Journal); technology (e.g., International Journal of Computer Applications in Technology); and education (e.g., Higher Education Studies).

Researchers' countries/territories. Collaboration between researchers spanning different countries was evident in this study. Of the 77 selected publications, 33 involved collaborations by researchers within the same country, while the remaining 44 articles reported inter-country collaborations among two or more nations. Figure 2 shows all the affiliated countries of these researchers and the number of articles that mentioned them. These countries were marked blue, ranging from the darkest to the lightest to symbolize their numerical ranking. The leading country with the most publications was found to be the U.S., which accounted for nearly half of the contributions (n = 30), followed by the United Kingdom (n = 10), Denmark (n = 7), the Netherlands (n = 7), and Spain (n = 6), and so on.

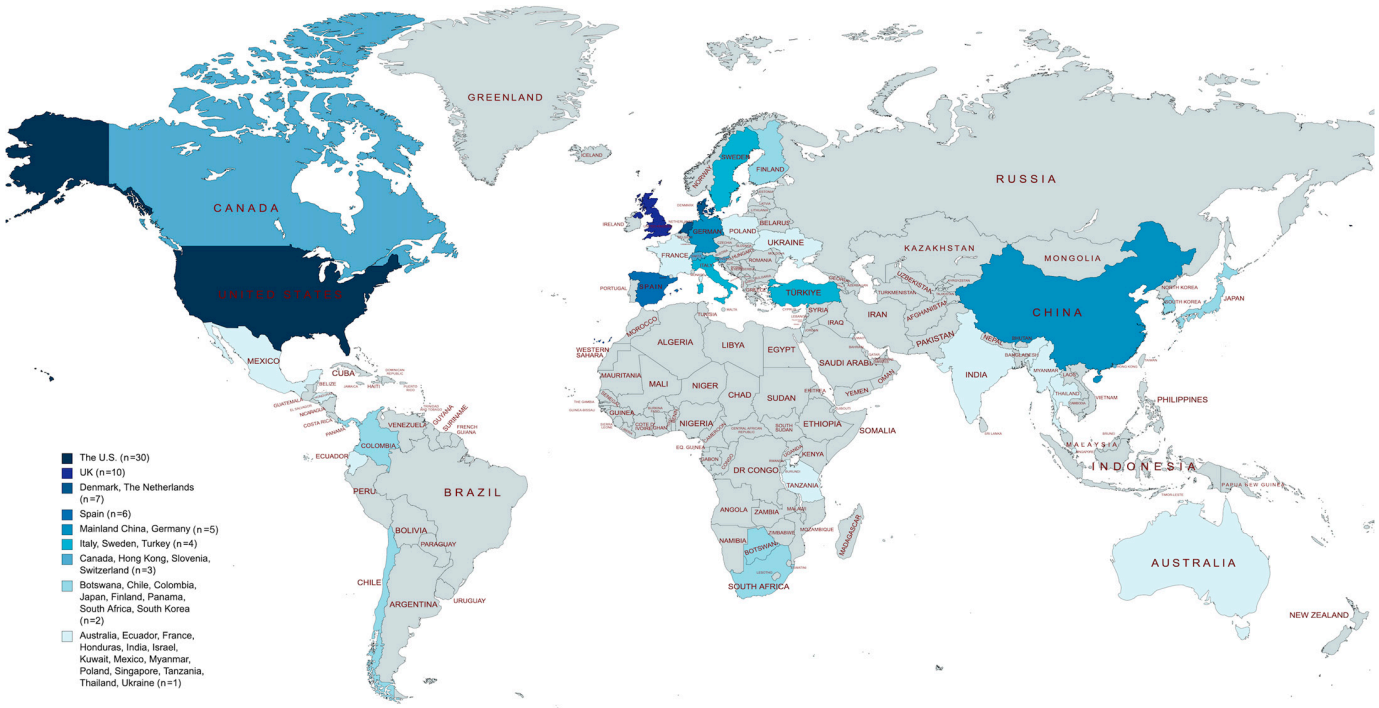

Figure 2. Affiliation countries reported in all included publications.

Study participants. A total of 53 out of 77 studies specified the students' disciplines. Among them, participants from 18 studies collaborated within one single engineering discipline. Twenty-one studies were conducted across multiple engineering disciplines, while fourteen articles reported multidisciplinary team collaboration or data collected from different disciplines, which not only included members from the engineering fields, but also from other STEM disciplines (e.g., chemistry, biology, physics, etc.), as well as social science, business, and management. Within the engineering fields, the reported studies mainly focused on mechanical engineering (n = 15), computer and software engineering (n = 15), electronic and electrical (n = 13), civil engineering (n = 9), and design engineering (n = 7). Other research was conducted in the areas such as architectural engineering, bioengineering, chemical engineering, environmental engineering, mechatronic engineering, industrial engineering, and so on.

While several studies mentioned student teamwork in the context of multi- or interdisciplinary approaches, only 16 articles linked cultural or intercultural issues to the students' academic disciplines. While all sixteen of these studies considered interdisciplinarity as a cultural variable, only two of these articles found that the differences between the disciplines were more prominent than the differences between the nationalities in their studies [27,28].

Research Methods and number of participants. Most of the studies (n = 30) employed mixed methods, combining qualitative approaches (e.g., observations, interviews, focus groups, reflective journals, etc.) with quantitative approaches (e.g., surveys, pre- and post-tests, etc.). There were 19 qualitative studies, the majority of which used interviews, observations, and document analysis. Fifteen studies used quantitative data collection and analysis, mainly in the form of surveys or questionnaires. These 64 research papers gathered data from various numbers of participants: fewer than 20 (n = 16), 20–50 (n = 21), 51–100 (n = 15), or more than 100 participants (n = 10), respectively. Two studies did not provide an exact number of participants. The research methods were not specified in the remaining 13 papers regarding project design or introduction of practice.

Analytical theories or framework. This was specified in 32 out of 77 articles. Several studies employed more than one theory or model to perform their analysis. The analytical theories or frameworks used in these articles can be categorized as follows: (1) active learning theories (e.g., problem- and project-based learning (PBL), experiential learning, service learning, and collaborative learning, etc.) (n = 18); (2) theories related to culture (e.g., Hofstede's cultural theory, socio-cultural theory, etc.) (n = 6); (3) theoretical models (e.g., the BIM model, the Revit model, the iceberg model, the dual-team model, etc.) (n = 13); and (4) other theories (such as the rhetorical theory and socio-constructivism) (n = 2). PBL (problem- and project-based learning) was found to be the most frequently employed analytical theory (n = 11), followed by Hofstede's cultural theory (n = 4).

Year of Publication. Figure 3 illustrates the number of papers in the sample published in each year from 2000 to 2022.

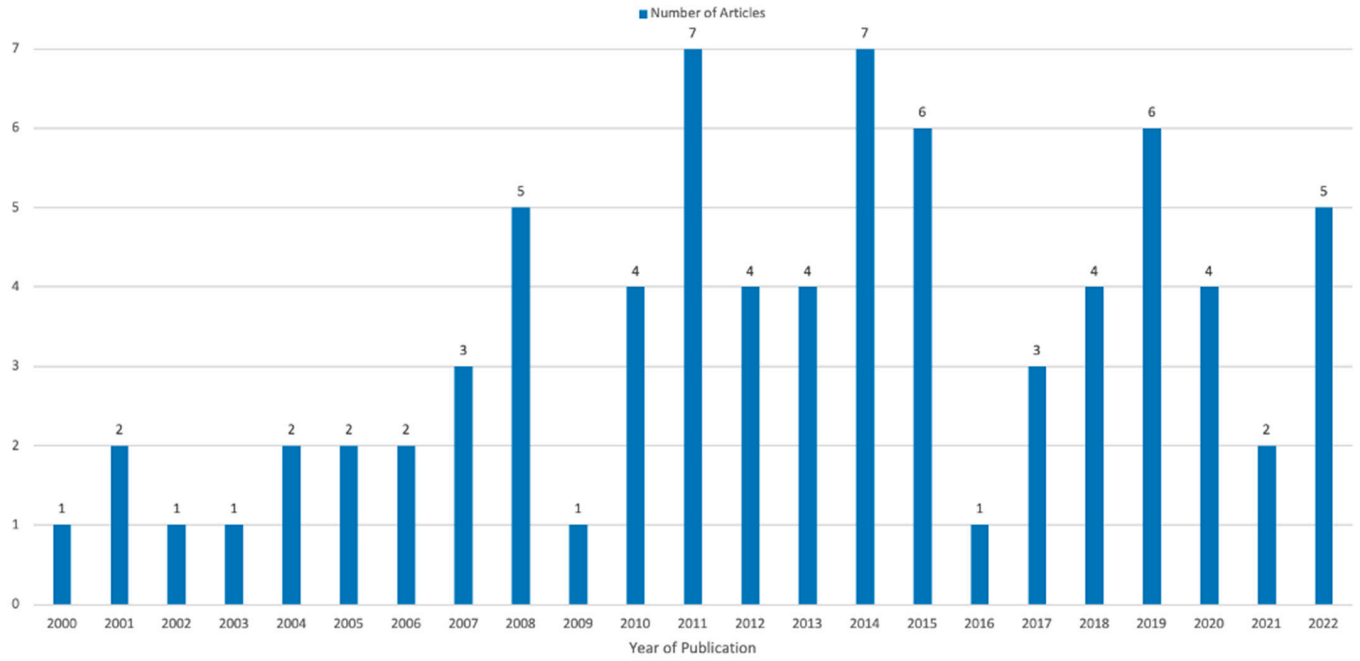

Figure 3. Year of publication and corresponding number of articles.

3. Findings

Consistent with our process of analysis, and for the purpose of answering our research questions, these findings offered details regarding intercultural team characteristics based on team formats, collaborative countries, level of collaboration, learning goals and prepara-

tion for intercultural teamwork, evaluation methods, and learning gains. The intercultural team challenges identified in the sample studies and the relevant coping strategies adopted by students were also explored in this section.

3.1. Intercultural Team Formats

Our review found that students collaborated in different structures and formats, as shown in Figure 4. Around one-third of papers (n = 26) reported that students worked together in culturally-mixed groups for projects or courses organized by their own or other institutions. Teams may be composed of both home and international students with diverse backgrounds from different engineering faculties within one university, or students from several institutions within the same country. The latter was only shown in a single study by Downey et al. [10]. Another one-third of papers (n = 25) indicated that student groups located in different parts of the world worked on projects or common tasks online, mainly communicating through various virtual tools such as emails, video- or tele- conferencing, and other synchronous or asynchronous collaborative software such as Skype, Facebook, Google Hangouts, Trello, etc. [29–31]. This type of team structure is becoming more common due to technological advancements, and the increasing demand for remote work arrangements [32,33]. Fifteen articles revealed that engineering students from different universities across various countries collaborated on global joint projects on-site. These projects were each primarily hosted by one university, which invited students at other universities from various countries to participate.

Six studies reported that teams were formed within an institution and students collaborated with international communities, mentors, or companies for project work or course work. For instance, in Borg and Zitomer's [34] research, students from an American university joined an international engineering service-learning project to improve the solar-powered water pumping system used by an orphanage in Guatemala. In another study conducted by Fox et al. [35], a partnership on a course was described by students from a U.S. institution, students from a German institution, as well as German industries. This course emphasized the concepts of sustainability and globalization to engineering students, as well as providing practical industrial experience in the global context.

Three studies described engineering students who worked in teams for short-term international field trips in 2–6 weeks to learn more about different cultures and gain practical engineering experience [36–38]. Students also developed their teams in international competitions, which challenged them with more complex engineering problems (e.g., [39,40]).

Figure 4 shows a breakdown of the structure, size, level of collaboration, learning goals of student teams and evaluation methods. The latter three will be explained in Sections 3.3 and 3.4. In most cases, students formed small groups with one to four members, followed by medium-sized groups of approximately five to eight members. Only six studies demonstrated student collaboration in large groups of more than eight members. To improve team building and foster intercultural communication and collaboration, engineering students were reported to attend various formal and informal team activities such as joint symposia [31], lab work [41], group projects, role-playing simulations [42], outings, and social activities.

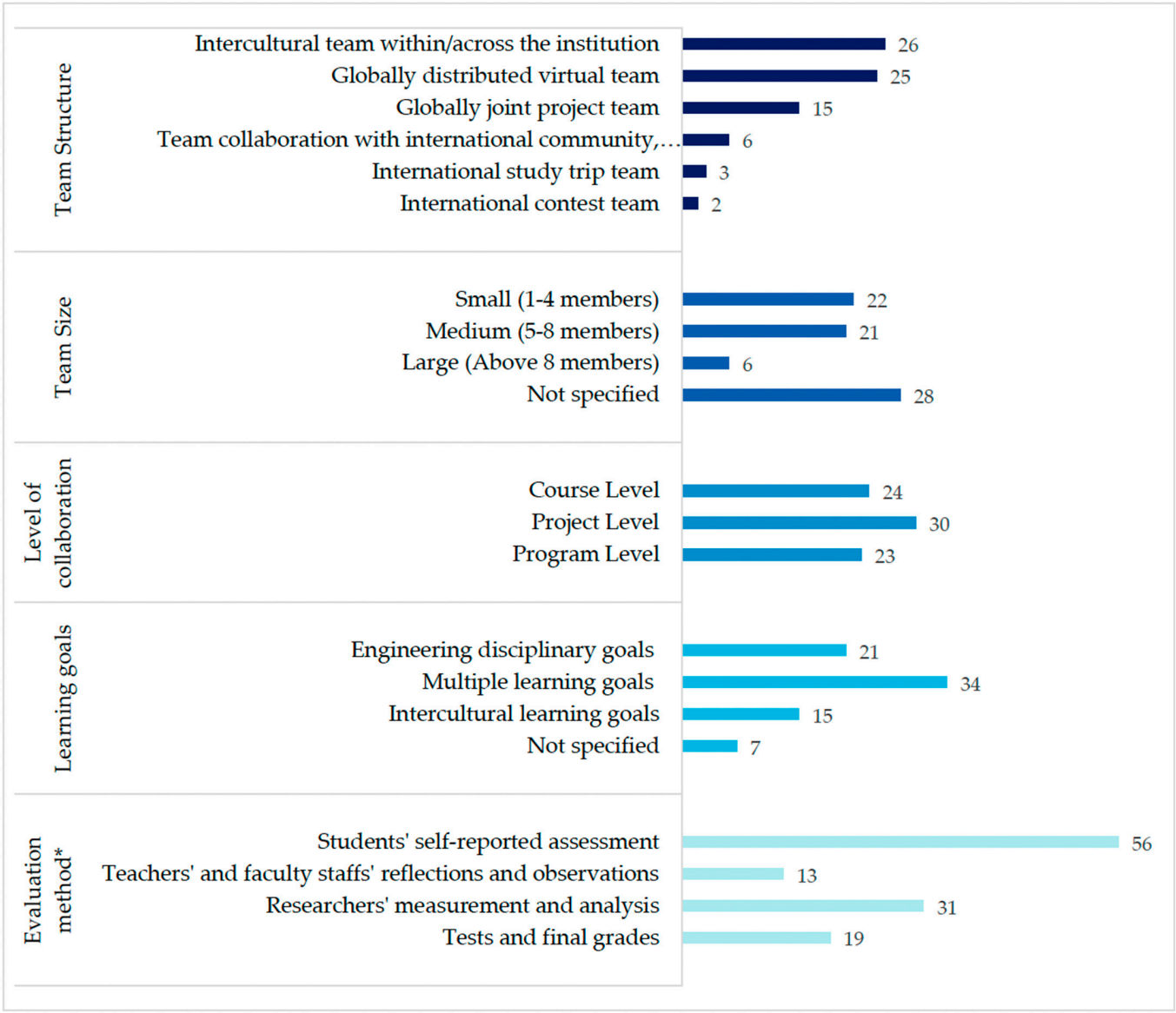

Figure 4. Number of articles in each subcategory of team structure, size, the collaboration level, learning goals, and evaluation method categories (N = 77). * Some articles reported two or more evaluation methods.

3.2. Collaborating Countries

This section highlights the specific countries in which the student teams were collaborating. Two articles did not specify the name of any country within the study, and the collaborations were discussed in terms of general intercultural contexts [40,43]. Student teams in 26 studies collaborated within the same country, including Denmark (n = 6), the United Kingdom (n = 5), the U.S. (n = 5), Canada (n = 2), and Spain (n = 2), respectively. The remaining six articles were each the sole study representing their country of origin; these countries included Italy, Japan, Kuwait, Singapore, Sweden, and the Netherlands.

Fifty-nine studies illustrated students' team collaboration across two or more countries. The collaborating countries from these 59 studies are shown in Figure 5. The lines in Figure 5 indicate the collaborative relationships that existed among the countries, while the line thickness represents the link strength or frequency of collaboration. To make the map clearer, countries in Europe were abbreviated as two-letter country codes, representing Finland (FI), France (FR), Germany (DE), Hungary (HU), Italy (IT), Lithuania (LT), Norway (NO), Poland (PL), Slovenia (SI), Spain (ES), Sweden (SE), Switzerland (CH), the Netherlands (NL),

the United Kingdom (UK), and Ukraine (UA), respectively. In the case where there were multiple countries collaborating in one single study, each country in the pair was counted in the frequency. For instance, in the study of Bufardi et al. [44], students from three countries—Switzerland, the Netherlands, and Slovenia—collaborated, and thus, the collaboration was counted three times; first between Switzerland and the Netherlands, second between Switzerland and Slovenia, and third between the Netherlands and Slovenia, respectively.

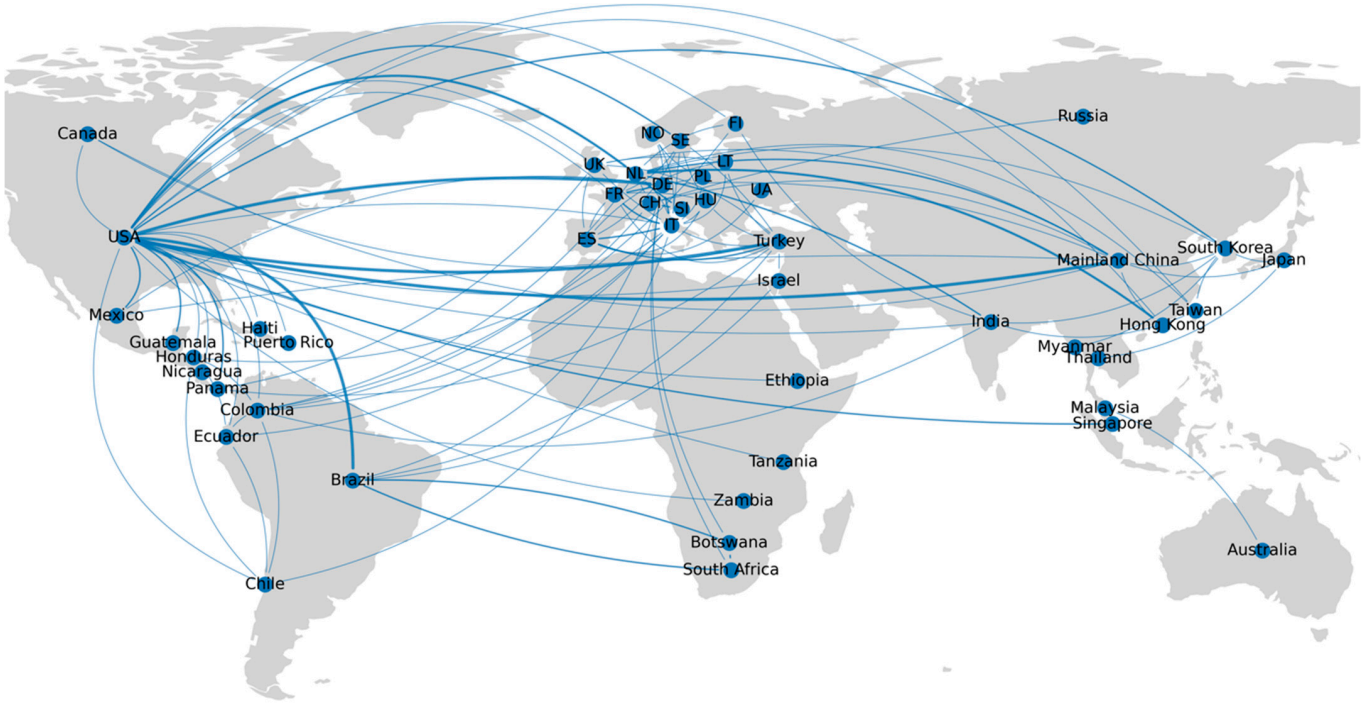

Figure 5. A map for country–collaboration networks.

In total, 165 collaborations among various countries were detailed within the sample of articles. The U.S. stood out as the top collaborating country with 63 international collaborations, the highest number. The next highest quantities of collaborations were observed in Italy (n = 20), Turkey (n = 19), the Netherlands (n = 19), Germany (n = 17), Mainland China (n = 15), Brazil (n = 11), Colombia (n = 11), France (n = 10), India (n = 10), Spain (n = 10), and the UK (n = 10), respectively. The remaining countries not mentioned above had less than 10 collaborations. The thickest lines between countries were between the USA and Brazil, the USA and Germany, the USA and Turkey, and the USA and Mainland China, respectively, which all represent the most intensive collaborations, shown in four studies each.

3.3. Level of Collaboration and Learning Goals

3.3.1. Level of Collaboration and Teamwork Preparation

Analysis of these 77 selected articles indicated that engineering students collaborated in intercultural teams at the course level, project level, and program levels (see Figure 4). At the course level, engineering students participated in their universities' international courses (e.g., [39,45]), cross-institutional collaborative courses (e.g., [10,46]), joint transnational online courses (e.g., [47]), or collaborative courses with industries (e.g., [35]). These courses were mostly short-term, ranging in duration from one week to one semester, and generally require students to work together to complete multiple tasks including group discussions, group presentations, group exercises, and/or course-related projects.

At the project level, engineering student groups joined a variety of projects which may have been organized by a single university (as was the case with the Innovative Design, Education, and Teamwork project [48,49]), or may have been conducted jointly

with higher education institutions (e.g., the Hong Kong-Netherlands project) [33,50,51], or with companies and communities (e.g., the International Capstone project [52]). In most project-level collaborations, students work full-time to complete their projects for approximately four to twelve weeks, in which they apply theories and techniques to solve problems, develop software, or design products.

At the program level, students participated in intercultural collaborations that were more systematic and repeated over the years. Teams are formed for a particular program which includes a structured set of lectures, trainings, workshops, group projects, laboratory experiments, and other activities that support students' professional learning and competence development [53–55]. Examples of such programs that were reported in these 23 studies include an articulation program [56,57], Global Engineering Teams [58], Innovation Research and Education of Asia [59], and European Project Semester [53,54,60]. These programs took place over a longer duration of time, ranging from one semester to five years or more.

Fourteen papers also demonstrated how students prepared for intercultural teamwork to ensure that every team member could work together effectively and break down barriers. Most of them (n = 11) reported that students attended cultural orientation courses such as courses on cross-cultural behaviors or teambuilding, technical courses for virtual teams, and language training courses held by the relevant institutions or programs [41,54,61]. In addition, a few of these 14 articles (n = 5) mentioned predeparture meetings before short-term study abroad, and informal social activities intended to develop a sense of group identity [38,48,62].

3.3.2. Learning Goals

Engineering students attempt to achieve a variety of learning goals through the above-mentioned courses, projects, and programs. The emphasis of each program's learning goals can be categorized into one of three types, which are as follows: (1) focusing on intercultural studies such as language and culture; (2) multiple goals including both engineering disciplinary studies and learning about culture/languages; and (3) focusing solely on engineering disciplinary studies. The number of articles in each category and corresponding papers are shown in Figure 4. However, learning goals were not specified in seven articles due to their primary research focusing on students' opinions about intercultural teamwork without further details of the courses, projects, or programs.

The courses, projects, or programs focusing on intercultural studies prioritized learning objectives that were intended to broaden the students' cultural and social experiences [34,63], build their appreciations for cultural diversity [10], develop their intercultural competence and linguistic skills [64,65], and help them behave appropriately in international teams [47].

Courses, projects, or programs with multiple goals combined cultural studies and engineering professional studies. From the analysis of the 34 selected articles in this category, these goals included dealing with ill-structured problems within global contexts [9,53]; developing software and increasing technical innovation for other countries [66,67]; acquiring knowledge about cross-cultural product design [20,44]; and developing professional communication and competence for the international workplace [33,68].

Goals that focused primarily on engineering disciplinary studies were described in the 21 studies. In these courses, projects, or programs, cultural learning was not prioritized. The engineering students' goals were to acquire the skills and knowledge necessary for becoming a professional engineer or a product designer. More specifically, these goals may include generating a model in specific software [32]; developing digital resources [48]; tackling engineering challenges [69]; and gaining project experience [62], among others.

3.4. Evaluation Methods and Learning Gains of Intercultural Team Collaboration

3.4.1. Evaluation Methods

Within the included 77 articles, several methods of evaluating engineering students' learning outcomes for intercultural teamwork were reported. These can be summarized into four main categories which are as follows: (1) students' self-reported assessments; (2) the reflections or observations of the teachers or faculty staff; (3) researchers' measurements or discussions; and (4) language tests and grading of team contribution. Several articles reported two or more evaluation methods. The number of articles using each category of method is shown in Figure 4.

Students' self-reported qualitative or quantitative assessments were reported with the highest frequency (n = 56). We did not count the frequency of each assessment method reported by students as they were combined in several articles, but examples are given below. Quantitative pre- and post-surveys are gathered to measure the changes in respondents' skills, interest, attitudes, and knowledge following their participation in courses, projects, or programs [9,50]. Furthermore, survey-based questionnaires with relatively large numbers of respondents are conducted to assess students' opinions and level of satisfaction with their intercultural teams [39,70]. Several surveys also posed open-ended questions which allowed the respondents to provide more detailed and personal reflections [34]. Students' intercultural learning is qualitatively evaluated by means of individual interviews with students, focus groups, reflective journals, and blog posts [16,68,71], etc. Students' self- and peer assessments are also evaluated; these primarily include periodic self-reflection reports and peer-written feedback on their own and other members' contributions [8,60]. Both of these forms of assessment enabled students to reflect on their own or their team's progress with intercultural working, identify areas for improvement [16], increase group efficacy, think critically about the competences that intercultural collaboration requires, and find solutions to tackle their challenges.

Teachers' or faculty staff members' reflections and observations were reported in 13 articles. For instance, Bani-Hani et al. [22] designed a survey to investigate university staff's opinions about challenges in students' intercultural team building, the suitable number of members for a team, and team performance. Grimheden and Hanson [72] conducted in-depth interviews with course teachers to gather information on students' learning gains in virtual team collaborations between the Royal Institute of Technology in Sweden and Stanford University in the U.S. Through observing videotaped students' meetings and having conversations with them, university staff in the study conducted by Grimheden and Strömdahl [73] were able to identify the difficulties that students encountered in online intercultural team interactions.

Researchers performed measurements and analyses in a total of 31 articles. In these research papers, researchers measured student learning through quantitative and qualitative analysis of students' team interactions [74,75], and participant or classroom observations of changes in team behavior [69,76,77]. For project design and the introduction of practice papers, researchers mainly discussed about intercultural learning outcomes.

With regard to tests and final grades (n = 19), students' team performances and contributions were evaluated through the assessment of group assignments or the grading of group final reports and presentations [78,79]. Language tests were also used in some studies to measure the students' language proficiency after working in an intercultural team [61].

3.4.2. Learning Gains

From the evaluations mentioned above, 65 of 77 articles discussed the students' learning gains from their international team experiences. Using both inductive and thematic analysis, five aspects of learning gains emerged as follows: (1) cognitive development; (2) affective development; (3) competence improvement; (4) behavioral adjustment; and (5) relations with larger contexts. These are listed in Table 3 and will be further explained below.

The first theme is students' cognitive development. This refers to students' acquisition, and the improvement of their understanding, awareness, and knowledge of basic intercultural values and traits [80–82], and of the engineering profession. First, working on an intercultural team cultivated the engineering students' confidence in their understanding of a wide range of views and cultures [16], and of the complexity of ongoing engineering problems in both global and societal contexts [34,42]. The integration of others' cultural and disciplinary views and practices encouraged the generation of new ideas and alternative solutions when exploring complicated engineering challenges [40,47]. Second, students also became more aware of the finer details of the similarities and differences between their own culture and other cultures [55], of how to interact with people from different countries in a respectful and meaningful way [38], and of the social and environmental realities [16]. A greater intercultural awareness can facilitate students' effective communication across the boundaries of nationality, promote diversity in teams, and help individuals to interact with others in various settings. Finally, students gained more comprehensive information and knowledge regarding social and cultural issues [37], co-created meaningful professional knowledge such as sustainable development or mechatronic practices [42,72], and learned to implement technologies in different situations [9]. Brennan et al. [83] revealed that, based on their improved understanding and increased knowledge, student levels of self-efficacy in cultural adaptation and problem analysis were also improved.

The second theme that emerged was the students' affective development. This includes emotions, empathy, open-mindedness, tolerance of uncertainty, curiosity, and attitudes toward different cultures and cross-cultural environments [81,82]. The selected papers indicated that students overcame their shyness and reluctance towards collaboration [84]; respected other members' contributions and cultures more [47,68]; increased their openness to different views [85]; and gained sensitivity to differences among cultures and local policies [38,47]. Through the process of collaboration, students became more curious about different engineering practices in other countries [47], more confident in communicating on intercultural teams and dealing with complex and real-world engineering problems [16,50], and more intrinsically motivated to explore intercultural learning for engineering [86]. As their mutual help and support increased, students felt more accepted by their teams and developed a sense of connection and belonging [51,71].

The third theme is related to students' competence development, i.e., the process through which students develop their skills and abilities to be more effective and successful in the intercultural environment [87], as well as in the engineering profession. Professionally, students were observed to become more competent in identifying, formulating, and solving engineering and social problems [34]; designing real-life products [88]; taking professional and ethical responsibility [37]; applying their knowledge of mathematics, science, and engineering in practice [83]; thinking in a critical and contextual manner [47,55]; effectively presenting their work and writing reports [64]; managing cross-cultural and cross-disciplinary research [62]; and being innovative and creative in their projects [59,88].

In addition, they learned how to manage their time and make plans regarding budgets, schedules, or construction [16,55]. Students were also reported be more capable of working collaboratively and communicating effectively with other team members [66]; functioning in multidisciplinary teams [37]; making decisions together [45]; taking team responsibilities and contributions [85]; taking leadership in terms of the project work [30]; resolving intercultural conflicts [40]; helping and trusting each other [89]; sharing knowledge and co-creating meanings [77]; keeping the team at the same pace [32]; developing team interactions and discussions [69,90]; and communicating proficiently in other languages [61,86]. Students also improved their capacity to effectively use a range of tools and technologies [33]; understand the relationship between technological innovation and social innovation [67]; and develop models using global software [91]. In the future, these skills will be beneficial when working and interacting with people from diverse cultures in the global workplace [28,68].

The fourth theme is connected to students' behavioral adjustment, or their ability to adapt their behaviors to the cultural and social norms of a new environment [81,82]. Students changed from initially observing others to ultimately becoming active participants in intercultural teamwork and discussions [66,92], accomplishing collective learning and problem-solving goals [58], and providing others prompt feedback and peer assessment [16]. In order to perform more effectively in international teams, engineering students adapted their communication and working styles based on the cultures of other students [93], and provided flexible environments for every team member to work on projects more freely [73].

The last theme focuses on the student teams' increased interactions with other stakeholders, such as communities, industries, and their international mentors. With more collaboration through projects, they not only gained experience with a variety of interactional norms [71], but also understood the relationship between technical systems and social innovation [67].

Table 3. Learning Gains of Intercultural Team Experience (* Duplicates Removed).

Themes and Number of Articles *	Content and Paper
Not specified (n = 12)	[27,35,36,43,44,48,49,57,65,78,94,95]
Cognitive development (n = 38)	• Increased understanding of engineering problems in global contexts [10,16,34,42,45,67,70,75,79] • Increased awareness on cultural differences [9,15,16,21,28,33,38,41,46,50,54,55,68,71,72,79,96] • Increased cross-cultural, technical, and professional knowledge [9,10,21,33,34,38,41,42,45,51,66,71,72,79,85,86,90,97] • Creation of new ideas from different views [16,28,31,40–42,47,53,64,66,70,85] • Increased level of self-efficacy [83]
Affective development (n = 27)	• Increased openness, respect, and sensitivity to other cultures [8,9,16,28,38,41,45,47,55,58,64,68,84,85] • Increased confidence in project work and intercultural interactions [9,16,30,40,50,51,55,61,71,90,92] • Increased curiosity to learn engineering practices from different countries [47,68] • Increased motivation and interest in intercultural and engineering learning [9,16,60,72,86] • Increased feelings of belonging and acceptance [51,62,71,90,97]
Competence improvement (n = 52)	• Improved professional skills • [9,16,29,30,34,37,42,47,55,58,59,62,70–72,79,83,88,90] • Improved collaborative and teamwork skills [8–10,15,16,21,22,29,30,32,37,38,40,42,45,51,52,55,56,58,66,68–70,73,76,77,85,88–90,92,94,96,98,99] • Improved communication skills [9,15,16,30,38,42,45,58,60–63,71–73,78,79,86,88,90,93,96,99] • Improved project management skills [16,22,32,33,40,55,62,66,70] • Improved technical skills [9,50,55,61,67,71,74,86,89,91,99]
Behavioral adjustment (n = 16)	• Increased active engagement in team meetings [16,47,62,66,92] • Improved appropriate actions in intercultural collaborations [20,33,47,71,91–93] • Improved flexibility in completing tasks [8,73] • Increased intercultural team feedback and assessments [16] • Managing more to achieve shared learning goals [8,39,40,58,62,91,97]
Interactions with larger contexts (n = 6)	• Increased experience and interactions with communities, industries, and mentors [52,55,62,67,71,92] • Increased social Innovation [67]

3.5. Intercultural Team Challenges and Coping Strategies

The papers included in this review reported a range of challenges faced by engineering students when working in intercultural teams. These challenges can be categorized into three levels, as shown in Appendix A: the individual, the relational, and the contextual levels. Challenges at the individual level are difficulties faced by the individuals, including those relating to language barriers, mental health, and prior background and experience. The relational level refers to the issues encountered when relating with others in teamwork

contexts, including challenges in time management and planning, interaction and communication, technology, and team building. The contextual level involves the challenges that are derived from larger socio-cultural contexts, including the lack of support from the faculty, staff, departments, and universities, or the lack of interaction with communities, companies, etc. The challenges described in the reviewed studies, along with the coping strategies students used to deal with these challenges, are elaborated below.

3.5.1. Individual Level

Linguistic challenges. The language barrier was the main individual-level challenge faced by students collaborating in international teams. As reported in the reviewed papers, linguistic challenges can include difficulty understanding specific accents and different languages [98], struggles in expressing opinions using a foreign language [9], and unfamiliarity with certain terminologies or jargon in other languages [16]. For better linguistic comprehension, native and advanced language speakers have tried to replace slang or jargon with simpler and more precise words, while non-native speakers utilized translation applications such as Google Translate or resources including translation booklets to communicate [62,66].

Psychological challenges. In the process of intercultural collaboration, students often struggled with psychological issues. For instance, in culturally-mixed teams within a single institution, several international students felt excluded from taking part in the project, and had little opportunity to participate in discussions and negotiations [90]. This challenge further decreased their confidence in voicing their opinions [30] and their enthusiasm to engage in team activities [45]. Some international students stated how they spent a considerable amount of time to adapt to the new international team contexts [78,90]. In addition, acclimating to other cultures can make them feel lost or struggle to identify their own identity and culture [21]. In addition, several local students held negative attitudes regarding intercultural collaboration, as shown by their prejudice and stereotypes about international students having different orientations to work and different levels of extroversion, and therefore being even harder to collaborate with than local students [28]. These stereotypes and prejudices can be harmful, and can lead to the marginalization and exclusion of members of other nationalities; they can also be disrespectful to groupmates [46]. Specific coping strategies for addressing these issues were not documented in the reviewed studies, but it was observed that students attempted to create a positive and inclusive team atmosphere as a means of addressing these problems [16].

Prior background and experience challenges. Engineering students were reported to have very limited experiences of working in intercultural teams [67]. Furthermore, it was also shown that students find compromising and negotiating within the group to be challenging when members possess differing backgrounds in professions, disciplines, and cultures [75], different levels of knowledge and competence [16], or insufficient professional and technical knowledge [45]. Again, specific strategies for addressing these issues were not clearly described in the literature, but several articles emphasized that students' learning on professions, technologies, and cultures improved over time [15,51].

3.5.2. Relational Level

Challenges for time management and planning. When working in a globally distributed team, time zone differences, including summer and winter time changes, present a challenge for students [73]. These differences make it harder for them to schedule a meeting on short notice for urgent matters [77]. When lacking explicit plans or an agenda for team meetings, students struggled with time pressure to finish their assignments on time [94]; displayed inconsistent project performance [91]; demonstrated inefficient working progress [99]; had arguments over daily tasks completion [16]; experienced task overlap [73]; and had work overload due to some less competent team members [45]. To manage stressful situations regarding time management and planning, especially in virtual teams, students held frequent meetings to learn about each other's progress [32]; made preparations for meetings, wrote

agendas and minutes [60]; defined work processes with deadlines for each task [20,51]; visualized working progress using tools such as Gantt charts [16]; and applied a "sandwich structure" alternating between synchronous meetings and asynchronous tasks [50].

Interactional and communicative challenges. Intercultural interaction or communication is one of the main obstacles engineering students face when working together in intercultural teams. Due to limitations of language, team cohesion, time, and space, students are hesitant to take part in team discussions, put forward their ideas, and give feedback [73,90]. Furthermore, the diversity of their cultural backgrounds, along with personal bias stemming from disciplinary differences, can lead to their communication with their teammates being unclear, confusing, or not well-received [51]. For instance, in Vogel's [51] study, Hong Kong accounting students perceived their Dutch technology management teammates as being too technical. In contrast, the Dutch students felt that the contributions of their Hong Kong counterparts were superficial, and that they lacked knowledge in some areas of the topic. These issues can therefore result in poor interactions and confusion during the progression of the project.

These limitations also lead to difficulties in managing different communication styles (e.g., expressive and straightforward communication vs. reserved and indirect communication) [15]; negotiations with different ideas and understandings [8]; and reluctance to build interpersonal relationships with each other outside of academic activities [57]. In some cases, the high costs of international study trips hindered students' face-to-face interactions [97]. To keep the team on the same level of understanding, students asked questions and explained the more challenging aspects of their work through written texts [66], visual help (e.g., drawings, sketches, tables, etc.) [20], and social media [32]. In order to build interpersonal relationships, several teams met before the start of the project to get to know each other [90], held social gathering events [71], and discussed their cultural differences [8].

Technological challenges. This type of challenge arose when using technology in a virtual team setting. Delayed team discussions and slow response times from some team members resulted from slow or unreliable internet connections [67], as well as outdated hardware and software [74]. In addition, students' unfamiliarity with some software and their difficulties in using the new technology led to data misinterpretations and ambiguity [32].

Without having proper communication and guidance, team members could end up using different versions of certain software or tools on project work, which can therefore prevent file sharing and information transfer [66]. In some international service-learning projects, the lack of equipment and software availability in local communities also caused difficulties for project completion and collaboration [52]. To minimize the technological problems, several universities have introduced new collaborative platforms for students [69], upgraded their facilities and tools [58], and provided students with extra trainings on how to use the relevant tools [50]. Student teams not only selected the most useful tools for collaboration, but also employed multiple technologies to foster stronger communication and understanding [33,93].

Challenges for teamwork and team building. Several challenges were demonstrated in students' intercultural teamwork. First, students felt ambiguous regarding their team roles and responsibilities as a result of their different perceptions of work procedures, lack of familiarity with their teammates, and inefficient communication. It was also a challenge that new members were added to teams after the projects had already begun [15,16]. In response to these difficulties, students took team role or personality tests such as the Belbin self-perception inventory test to clarify their roles and responsibilities that they could take on to help complete their team projects [33,54]. They also designed team contracts which outlined the organizational structure of their groups, the role of each group member, and the responsibilities and work process of each role [45].

Another teamwork challenge laid in the fact that some passive learners can be reluctant to contribute to ideas [58], accept challenging tasks [30], or participate in discussions and project work [92]. To motivate every member, teams assigned tasks based on their strengths

and areas of needed improvement [16,22]. Furthermore, members of several teams also took turns as the team leaders or coordinators [74].

A final challenge in this area stems from group formation across disciplines and cultures [27], and a lack of team trust [89]. This can make it even more difficult for group members to compromise between different working and learning habits [78], set common learning goals [16], and make decisions [91]. To build a more inclusive atmosphere, students tried to understand members' cultural and disciplinary differences [64], actively participated in the ice-breaking activities [49], and took initiative in discussing what learning goals they intended to achieve together [16].

3.5.3. Contextual Level

Challenges in team relationships with other stakeholders. Alongside the challenges within their group work, students also confronted relational issues with their project supervisors, industrial mentors, consumers, companies, or local communities. To be more specific, faculty and supervisors often gave little guidance of how to work effectively in an international team, and provided little support as the projects progressed [56,73]. When designing products for companies, student teams struggled to accommodate the needs of their different international clients [98]. In joint projects with local communities in another country, students were obliged to abide by local regulations and understand the local conditions [52,66]. However, strategies were more focused on addressing the relationships between students and stakeholders within the university such as faculty staff and institutions. For instance, students took the initiative in communicating with their supervisors to ask for better suggestions [16], and participated in cultural orientation courses or activities organized by their institutions [63,76]. To coordinate the intercultural teams, the faculty aimed to provide their students with more useful tools in team organization and decision-making [55], and give prompt feedback on their project progression, technology use, and team collaboration [33].

4. Discussion and Conclusions

This study set out to provide a comprehensive overview of peer-reviewed journal articles on the current characteristics of intercultural teamwork among engineering students, the challenges students face in intercultural teams, and the coping strategies they employ in response. By consulting five databases (SCOPUS, Engineering Village, ERIC via ProQuest, Web of Science, and EBSCO) and using a systematic filtering process, 77 articles were included in this study, and a wide range of intercultural team characteristics were identified based on the collaborating countries, team formats, levels of collaboration, learning goals, evaluation methods, and learning gains. Additionally, intercultural team challenges at the individual, relational, and contextual levels were described, along with the relevant coping strategies students adopted in response to these challenges. These findings have the following practical implications and future research directions.

First, in this systematic review we followed the culture-as-construct approach proposed by Handford et al. [11] to conceptualize culture. This approach means that individuals co-construct their meanings and interact dynamically with others regardless of national boundaries. In this sense, national culture is one of the variables in the construction of one's identity. Other variables may include one's academic background, discipline, ethnicity, institutions, or lived learning and international experiences [21]. In our analysis, however, most included studies were found to limit their understanding of culture to one's nationality, geographic region, or institutions. Only a few studies conceptualized culture at the multidisciplinary or inter-disciplinary levels, and there was a general lack of recognition and discussion of ethnic cultures. Therefore, when organizing and coordinating intercultural team activities, teachers and academic staff should consider the inclusion of students with diverse backgrounds not only in terms of different nationalities, but also in terms of the various ethnic groups and disciplines within engineering and beyond. This finding echoes previous studies which called for researchers to examine the societal and intercultural

dimensions of broad interdisciplinary issues [100]. It has also been suggested that future works should elaborate further on aspects such as ethnicity, and comprehensively enhance intercultural diversity.

Second, adequate preparation for intercultural teamwork is necessary to reduce confusion and increase group effectiveness [62]. However, only a small number of studies discussed engineering students' preparation for intercultural teamwork. The majority of these students reported that they attended language, cultural orientation, or technology courses before the team was established. Therefore, it has been recommended that engineering educators and instructors should design more formal and informal preparation activities to help students adapt to working in an intercultural team. Additionally, very few studies mentioned theories related to culture. At the preparation stage, more theories that highlight the interactive and dynamic characteristics of culture could be introduced by teachers to help students understand intercultural teamwork from a theoretical perspective.

Third, although this review has reported the use of four different categories of evaluation methods in the reviewed articles, evaluation by teachers or faculty staff members is the least frequently reported method. This finding suggests that researchers should collect more data from teachers or faculty staff in future work, so as to investigate their perceptions with regard to facilitating intercultural student teams and their opinions of intercultural team challenges.

Fourth, students' learning gains were classed into five key categories, and most studies indicated that learning gains included improved competence when working on intercultural teams, increased knowledge and awareness of both professional and intercultural learning, and affective development [47,61,68,90]. However, only a few articles revealed actual behavioral changes, and even fewer discussed effective interactions with external settings and other stakeholders [62,71,92]. A gap in understanding thus exists between the cognitive and affective developments of students and their actual process of intercultural practices, as well as passivity in their interactions with the wider settings [8]. This echoes the findings of earlier studies in that improved intercultural awareness and knowledge does not necessarily lead to better external interactions and behavioral changes in interculturality [101,102]. This underlines the need to encourage engineering students to be more proactive when participating in intercultural teamwork by making independent choices, taking ownership of authentic tasks and collaborative practices, and developing their collective agency [2,16,103]. Although the included articles have focused on the phenomena of behavioral changes such as behavioral flexibility (e.g., [8,73]) or behavioral adaptation to intercultural teams (e.g., [47,91]), future studies could further explore what elements cause engineering students' behavioral changes and external interactions in intercultural environments.

Fifth, several coping mechanisms for addressing these challenges have been identified, but how engineering students overcame their individual psychological issues in intercultural team environments were not specified. For culturally-mixed teams within institutions, although some international students were able to manage their isolation and anxiety through engaging with cultural orientation events or by building interpersonal relations with others, it has also been suggested that universities and engineering educators should develop on-campus counselling centers, offer structured and relevant lectures, and give advice for local students to help them understand the specific cultures of their international teammates.

For global virtual teams, previous studies have indicated that students' online intercultural communication seldom develops to a higher level [104], pointing to the need for enhanced facilitation and guidance from instructors. Inspired by the work of Artino and Stephens [105] and Baek et al. [67], it was therefore suggested that lecturers should facilitate effective online discussions among different cultural groups, reinforcing students' contributions, requesting explanations when necessary, and assessing student misunderstandings. Furthermore, program managers and collaborating institutions should be more mindful about differences among the collaborating countries when providing access to resources

and training, and should create a safe, open, supportive, flexible, and adaptable environment for all students. This would support engineering students to develop their efficacy, motivation, intercultural awareness, self-regulation skills, and cross-cultural interactions in the intercultural online environment.

The reviewed articles' discussions of coping strategies at the contextual level focused primarily on addressing student–instructor or student–institution relationships, without paying sufficient attention on how to build relations with other stakeholders, such as international clients, international companies, and local communities. In light of this, it was therefore advised that universities should introduce students to basic information about the companies they will be working with before the project commences. Universities could also hold more frequent meetings and invite companies and engineering students to discuss their expectations from both sides. In order to work more effectively in local communities, site visits are crucial, and students should be introduced to the local rules and local environments by project managers when designing their projects [52].

Despite generating these useful recommendations, this study is also subject to several limitations. First, the scope was limited to five databases, peer-reviewed journal articles written in English, and materials published in the past two decades. Therefore, there was a lack of further information about intercultural teamwork reported in conference papers, non-English journals, non-academic reports and articles, contributive theses and dissertations, grey literature, and other databases, which could have led to bias in our findings. However, the auditing process mentioned in Section 2.2.2 could have minimized the risk of bias from researchers, and therefore presented our results more objectively [106]. Second, the title screening approach was adopted at the first stage, and thereby 489 papers were removed. Through this process, several important journal papers may have been left out in the case where they were relevant to the characteristics of intercultural teamwork and team challenges but did not clearly state this in their titles and abstracts. This limitation has been reduced through our reference list checking of the selected papers after the database search. More alternative methods, such as key journal searching and key author searching, could also be used in the future. Third, neither the theoretical framework to support students' intercultural team learning, nor the factors impacting their learning effectiveness in team contexts, were investigated in depth. Future review work should analyze and report how cultural theories guide student behaviors when working in a team and make comparisons between the different cultural groups.

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Appendix A Challenges and Coping Strategies Reported under Three Levels

Table A1. Challenges and coping strategies reported at three levels with article numbers.

Individual level	
Challenges	Coping strategies
Linguistic challenges (*n* = 24) • Difficulty in understanding specific accents and languages • Difficulty in speaking other languages • Unfamiliarity of technical words or jargon	Coping strategies for linguistic problems (*n* = 6) • Avoidance of slang/colloquialism/jargon • Using simpler and more precise language • Using translation apps
Psychological challenges (*n* = 25) • Feelings of loneliness and exclusion • Loss of confidence and motivation • Confusion about cultural and professional identity • Adaptation to new cultural environment • Negative attitudes toward intercultural team collaboration • Reluctance to ask for help	Not specified
Challenges for prior background and experience (*n* = 30) • Lack of knowledge about intercultural team collaboration • Weak professional and technical backgrounds • Discrepancies between academic and cultural backgrounds	Not specified
Relational level	
Challenges	Coping strategies
Challenges of time management and planning (*n* = 31) • Time zone coordination • Time crunch for team tasks and meetings • Lack of explicit team plans • Inconsistency of working progress • Heavy team workload • Conflicts and disagreement about task progression	Coping strategies for time-related and planning issues (*n* = 11) • Frequent meetings to keep up-to-date with each other's progress • Written agendas and timing for meetings • Planning in advance • Clearly specifying deadlines for team tasks • Visualizing working progress through project management tools • Using the "sandwich structure"
Interactional challenges (*n* = 38) • Limited team discussion • Ineffective communication • Differences in communication styles • Negotiation with different opinions and understandings • High cost of international field trips and on-site collaboration • Lack of peer feedback • Lack of interpersonal relationships/interactions	Strategies for ensuring effective communication and interaction (*n* = 24) • Explanations of misunderstood aspects of projects • Asking for clarification • Using a variety of tools and ways to communicate • Early meetings to get to know each other • Developing shared theories and knowledge • Social gatherings outside of academic activities • Informal conversations about cultures
Technological challenges (*n* = 21) • Unstable internet connections • Unfamiliarity with software • Not maintaining the same pattern of tool use • Poor technical quality • Lack of equipment or software	Strategies for dealing with technological problems (*n* = 11) • Introducing new platforms • Tool and facilities improvement • Choosing multiple effective technologies • Training for students about tool usage

Table A1. *Cont.*

Challenges for teamwork and team building (n = 33) • Team role confusion and uncertainty • Avoidance of team responsibility • Passive engagement in team tasks • Lack of trust between team members • Inappropriate team rules • Different working and learning habits • Unsuitable group composition • Lack of team goals • Difficulties in decision-making	Strategies for team building and improving team dynamics (n = 24) • Task distribution based on members' strengths and areas for improvement • Assigning coordinators or taking turns as team leaders • Clearly defining different team roles • Engagement in ice breaking exercises and sessions • Taking role tests to form groups • Designing team contracts • Balancing students' cultural backgrounds and disciplines • Discussing common learning goals
Contextual level	
Challenges	Coping strategies
Challenges for team relationship with other stakeholders (n = 8) • Lack of support from supervisors and institutions • Struggling to meet international clients' needs [52,67,98] • How to abide by rules of local communities and understand local conditions	Ways of addressing relationships between students and others (n = 14) • Asking for suggestions/help from supervisors • Participation in cultural orientation courses or activities organized by the institution • Support from faculty members to coordinate teams

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Paper 2

A Narrative Inquiry into Developing Learner Agency of Engineering Students in an Intercultural PBL Environment

Dan Jiang, Bettina Dahl and Xiangyun Du

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Paper 3

Engineering Students' Perception of Learner Agency Development in an Intercultural PBL (Problem- and Project-Based) Team Setting

Dan Jiang, Bettina Dahl, Juebei Chen and Xiangyun Du

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Engineering Students' Perception of Learner Agency Development in an Intercultural PBL (Problem- and Project-Based) Team Setting

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Abstract*—*Contribution: **This study explores the elements engineering students perceive as important for developing their learner agency in the context of intercultural project-based learning (PBL) teams.**

Background: **The concept of learner agency has recently gained prominence due to its relevance for student-centeredness, autonomy, self-regulation, and collaboration. Certain pedagogical approaches are known to specifically support the development of learner agency, including PBL, in which learners are provided with active, self-directed, and collaborative learning tasks. PBL practice is also increasingly diverse, emphasizing intercultural collaboration in teams. However, learner agency has received little research attention in PBL settings, and even less in intercultural PBL. This study contributes to the existing literature on the development of learner agency in intercultural PBL teams.**

Research Question: **What elements do engineering students consider important for supporting their learner agency development in an intercultural PBL team context?**

Methodology: **Theoretically, learner agency is framed within three interrelated dimensions, namely, intrapersonal, behavioral, and environmental. Based on this framework, a survey instrument with 31 items was constructed and responses were obtained from 310 engineering students. The survey used expert review, student piloting, exploratory factor analysis (EFA), and Cronbach's alpha to test content validity, construct validity, and reliability. The descriptive and demographic statistics were examined through *t*-test and the analysis of variance test.**

Findings: **Five factors emerged from EFA: 1) interest and motivation; 2) self-efficacy; 3) self-regulated behaviors in teams; 4) team dynamics; and 5) external support. The statistical analysis shows that the interest and motivation factor was perceived by the engineering students as the most important. Furthermore, several demographic variables, including gender, nationality, year of study, and type of PBL learner based on their level of experience with PBL, were found to impact engineering students' agency development.**

***Index Terms*—Engineering students, intercultural teams, learner agency, project-based learning (PBL), survey instrument design.**

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This work involved human subjects in the research. Approval of all ethical procedures and protocols was received from the Institutional Review Boards (IRBs) of Aalborg University and as registered in the General Data Protection Regulation (UE) 2016/679 GDPR.

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I. Introduction

LEARNER agency in higher education has emerged within the last decade as an increasingly important concept due to its connections with student-centeredness, decision making, autonomy, self-regulation, and collaboration [1], [2]. This concept encompasses a learner's will and capacity to take action within a given context [3]. Interactions between learners and their situated environments should be complex, dynamic, and nonlinear [1], [4], [5], [6]. Through agency, learners can take ownership of knowledge construction [7], contribute to one another's development, have an impact on their learning experience [8], engage in authentic tasks and collaborative practices [9], and anticipate their own learning outcomes [10]. Agency empowers learners to actively interact with or influence their situated environments, instead of passively reacting to them [11]. In this sense, educators in higher education should not only focus on learners' personal autonomy, but also on their wider relations with other instructors, peers, families, and communities that influence their learning [6].

In engineering education, learner agency is enhanced by pedagogical approaches and learning environments in which learners are given opportunities to be active and engaged in self-directed and collaborative learning [1], [2], [3], such as problem-based and project-based learning (PBL). PBL is "an instructional (and curricular) learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem" [12, p. 7]. In a PBL environment, engineering students are confronted with complex, ill-structured, real-world problems and challenged to develop viable solutions [13]. They work in small groups to manage projects, define knowledge gaps, co-construct the learning process, and develop strategies through sense making, interaction, and communication [14], [15].

Recent decades have witnessed PBL practices becoming more diverse, reflecting differences in cultural contexts and emphasizing international educational collaboration [16], [17]. Studies have investigated the impact of intercultural barriers encountered by engineering students in project teams, such as the accommodation of different professional and cultural identities, a diversity of educational and cultural backgrounds [18], language barriers and difficulties in communication [19], and different working and thinking habits [20].

Although learner agency has drawn increasing attention in higher and engineering education research generally, it has been scarcely examined in PBL settings, and much less in the intercultural PBL. While our initial studies provided qualitative data [21], an overview taking a quantitative approach has the potential to make a significant contribution to the literature on both learner agency and intercultural learning in the PBL context. It is also hoped that this quantitative research will generate deeper insights on higher engineering students' learning experience in an intercultural PBL team. Therefore, this study explores learner agency development in an intercultural PBL team setting through the development and use of a new survey instrument. The study is guided by the following question.

What elements do engineering students consider important for supporting their development of learner agency in an intercultural PBL team?

II. Literature Review

A. Conceptualizing Learner Agency

Originating from the social sciences, the concept of "agency" has gained growing attention in educational settings and research. It describes individuals' exercise of will and capacity to set goals, make independent choices, and take autonomous action in relation to these choices [22]. This concept has been widely explored and discussed in a range of views. For instance, the socio-cognitive perspective treats agency as a mediator between thoughts and actions, relating it to one's intentionality, self-efficacy, self-regulation, self-reflection, metacognition [23], motivations [24], and competence beliefs [25]. Collective agency among learners is shaped by the integration of knowledge, skills, and resources to pursue shared learning goals [11]. A subject-centered social-cultural approach defines agency as inherently interactive and socially constructive, with individuals developing cognition and conducting agentic actions within certain social, historical, or cultural contexts [5], [10]. These two perspectives conceptualize agency as dynamic and complex, linking to cognitive processes and intentional actions within a larger social context.

An OECD report has mentioned that learner agency encourages individuals to initiate their autonomy and responsibility to participate in learning activities within a complex and uncertain context [6]. Recent literature review in higher education research divides learner agency of students into a number of component types [26], with the most relevant to this study being relational agency [27], epistemic agency [9], and agency in relation to internationalization [28]. Relational agency does not just focus on students' personal autonomy, but also considers their interdependence, relational connections, and joint actions with others [27]. As described by [9], the epistemic agency is reported in collaborative activities in which groups co-create shared knowledge. The epistemic agency has knowledge-related and process-related dimensions [9]. The former involves awareness, shared understanding, and collaborative creations, whereas the latter includes regulative and relational behaviors, such as goal setting, monitoring progress, and redirecting critical feedback [9]. Regarding the agency related to internationalization, both student-initiated activities and co-created settings play a vital role in the formation of intercultural relationships [28]. Although these forms of learner agency are neither specifically discussed in intercultural teams, nor in a PBL environment, they provide a foundation for our development of a theoretical framework.

Some empirical studies have adopted constructivist and socio-cultural learning perspectives to explore the development of learner agency of students [10], [29], [30]. For instance, to assess student agency from a multidimensional perspective, Jääskelä et al. [29] constructed the agency of university students (AUS) scale. Analysis of the AUS scale relates agency development to students' access to personal resources (e.g., self-efficacy and competence beliefs), relational resources (e.g., teacher–student relations, peer support, and feelings of trust and safety), and contextual participatory resources (e.g., external help from teachers, courses, communities, or institutions), and to their participation in intentional, self-defined, autonomous, and meaningful learning activities [10], [29]. However, this scale still needs further examination within the engineering education field. Inspired by that study, Du et al. [30] discussed learner agency enactment within a PBL context in Qatar, and concluded that engineering students value external support and resources from instructors who provided direct guidance and authorized knowledge. Linking learner agency to sustainability in a systemic PBL context, Guerra et al. [31] reported that most engineering students acknowledged the importance of personal values of learner agency, such as motivation and efficacy beliefs. A gap is still existing between students' awareness and actual engagement in sustainability activities. However, these studies have not yet discussed learner agency development in an intercultural PBL team, nor have they investigated what engineering students value in such an environment.

To sum up, in this study, learner agency is conceptualized as a dynamic and complex system [2], [30], which includes three interrelated aspects.

1) Learners' sense of agency, measured through subjective perceptions of agency in a particular context [1], [2].
2) Learners' agentic behaviors, examined through choice-making and self-regulated learning [11], [23].
3) Learners' interactions with the situated environment (e.g., teamwork, classroom, peers, and communities), either deliberate or unconscious, active, or passive [5], [32].

B. Defining Intercultural Learning

To investigate intercultural learning, it is necessary to first define the concept of "culture." The complexity theory and constructivist views regard culture as "liquid," implying that it is a dynamic, constantly changing, action oriented, socially constructive process, and independent of national boundaries [33], [34]. The dynamic interaction between different cultures can be described as an interculture; hence, intercultural learning is an interactive process across cultural contexts in which learners interact with one another to construct intercultural mindsets and competence [35], [36].

Although several approaches exist to measuring intercultural learning, it is usually examined in three dimensions: cognitive, affective, and behavioral [37], [38], [39]. The cognitive dimension comprises learners' development of cultural self-awareness and knowledge acquisition. Awareness of culture is fundamental in intercultural learning as it supports the capacity to recognize and handle cultural differences [35]. To manage larger differences, learners must gain culture-general knowledge instead of knowledge about only one specific culture [36]. The affective dimension is concerned with learners' attitudes and sensitivity about cultures and intercultural contexts, as demonstrated by their openness, respect (i.e., valuing all cultures), curiosity, and discovery (tolerating uncertainty) [37]. The behavioral dimension relates to learners' ability to behave appropriately and effectively in intercultural situations through critical reflection, listening, observing, communicating, evaluating, and relating acquired cultural knowledge [37]. These behaviors are jointly developed by learners in small groups or larger entities within a given setting [35].

The increasing demands for internationalization and focus on cultural diversity in engineering education have incentivized researchers to quantify students' intercultural learning. For instance, Thompson and Jesiek [40] implemented the intercultural development inventory (IDI) to measure undergraduate engineering students' intercultural sensitivity. Their results found that female students had higher intercultural sensitivity than male students. The more recent study by Jesiek et al. [41] utilized a short version of the Universal-Diverse Orientation scale, aiming to examine engineering students' awareness of and appreciation for cultural diversity. The analysis revealed that the factors impacting these traits include students' academic year, prior experience, level of intercultural competence, and gender [41]. Other instruments, such as the cross-cultural adaptability inventory (CCAI) and global awareness profile (GAP) test, are used to assess intercultural effectiveness and awareness in global engineering education [42]. However, none of these tools have measured engineering students' learning within intercultural team settings. Therefore, it is necessary to address this research gap and generalize the result to wider population. Furthermore, most tools such as these focus on only one or two dimensions of intercultural learning. Hence, additional research is needed which investigates interculturality in a comprehensive manner.

III. Theoretical Framework

This study proposes a theoretical framework of learner agency within an intercultural PBL team setting, shown in Fig. 1. An intercultural PBL team in this study is defined as individuals from different cultures interact and negotiate with their members, other small groups, or even larger sociocultural settings to complete the projects and address complex and real-life problems together [21], [33], [34], [43]. The framework combines the three interrelated aspects of learner agency with the three dimensions of intercultural learning. This framework includes intrapersonal, behavioral, and environmental dimensions. The intrapersonal dimension includes affective and cognitive parts in intercultural learning and learners' sense of agency. The behavioral dimension includes both agentic and intercultural behaviors. The environmental dimension describes the interaction between the learner and their situated environments or a larger intercultural context. Each dimension will be explained in the following sections.

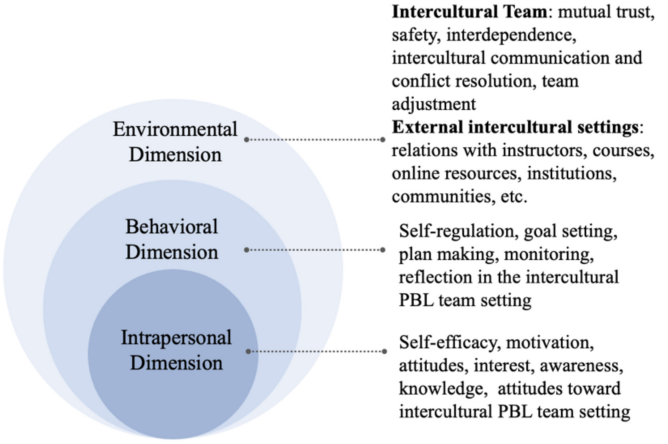

Fig. 1. Framework for learner agency in an intercultural PBL team setting (Adapted from [21, p. 1106]).

A. Intrapersonal Dimension

The intrapersonal dimension of learner agency includes cognitive, affective, and motivational elements, such as belief, efficacy, motivation, attitudes, and interest [30], of which the most influential are self-efficacy and motivation. Self-efficacy is defined as an individual's belief and confidence in their ability to organize and perform the learning activities necessary to reach certain goals [23]. It serves as a resource of agency, empowering students to take responsibility for their learning processes, achieve higher outcomes, persevere longer when confronted with challenges, and make efforts to take up challenges [29], [44]. In the international team context within PBL, students' agency improves if they believe that the environment is conducive to their professional learning and development of intercultural understanding [17], gain relevant knowledge for projects and teams [45], develop the required competence to reach their learning goals [30], improve their cultural awareness and sensitivity, develop respect as well as acceptance and tolerance of others [43], overcome intercultural challenges, and develop professional identity as engineers within a global context.

Motivation refers to an individual feeling inspired, oriented, activated, and satisfied to act in learning activities [24]. In PBL, motivated learners are driven by both intrinsic desire and external context to initiate action, find directions, identify authentic problems, develop interest in topics, and increase persistence and intensity in learning [43], [46]. The dynamic nature of motivation in an intercultural PBL team drives students to actively interact with others from different backgrounds and connect their personal traits with external and intercultural collaborations [17].

B. Behavioral Dimension

This dimension focuses on how learners self-regulate in complex learning situations, construct knowledge, and choose

appropriate behaviors [5]. Well-regulated learners are proactive in establishing goals and desired outcomes, making plans, regulating actions to reach goals, organizing multiple activities, monitoring the progress, adapting to new situations, and self-evaluating and reflecting on the learning process [11], [47].

As one of the sources of learner agency, self-regulation also incorporates relational elements. Specifically, in an intercultural PBL team, students generate common learning goals and plans, share useful and relevant information, search for multiple resources for project work, identify effective strategies for intercultural collaboration and communication, jointly evaluate the learning process, and make further adjustments [17], [48].

C. Environmental Dimension

The environmental dimension concerns learners' participation, interaction, and collaboration beyond the PBL team, within a wider intercultural setting [49]. Due to its relational and contextually bounded features, learner agency is supported or constrained by participatory resources. Team dynamics can be treated as one of the key resources. To investigate proactive teams and agentic individuals within teams, Borrego et al. [50] established five constructs for PBL team effectiveness in engineering education.

1) Avoidance of inactive participation and inclusion of all members' ideas and contributions.
2) Interdependence on others to accomplish tasks through complex projects, and group processing and grading.
3) Conflict management through the setting of clear goals and values, consensus decision making, regular group meeting attendance, balancing the project workload with members' needs, and awareness of conflicts.
4) Trust-building efforts.
5) Team process adjustments through monitoring, reflection, and adaptation.

Within intercultural PBL, students are presented with more cultural diversity in the group dynamics. This requires all team members to have effective intercultural communication skills [16], to foster openness and respect for other cultures [43], to improve their understanding of social and environmental realities, and to exercise participatory cross-cultural leadership [21].

In a PBL setting, contextual resources exist in reciprocal interactions not only with peers and teams, but also those with other external influences. These resources include support from instructors, courses that students attend, online resources, and practices in communities, institutions (e.g., policies, programs, or rules), or even broader sociocultural contexts [30].

In conclusion, while some prior research has explored student agency within higher and engineering education, little is known about how engineering students enact their agency in intercultural PBL teams. Therefore, the above-proposed framework serves as both a conceptual grounding and the basis for quantitative instrument design.

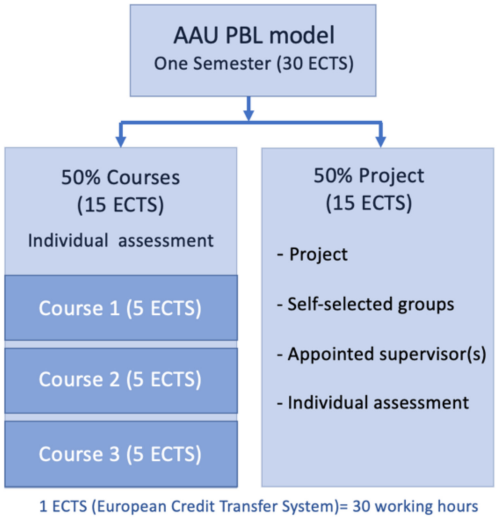

Fig. 2. Structure of AAU PBL model ([51, p. 292].

IV. Methods

A. Study Context

This study was conducted at Aalborg University (AAU), where the PBL model has been practiced for nearly half a century. At AAU, each semester is usually composed of 50% course modules and 50% team-based project modules [51]. Fig. 2 depicts the structure of the AAU PBL model. Students usually participate in three compulsory or elective courses in a total of 15 ECTS, which enable them to become familiar with disciplinary theories and methods involved in the projects. The courses include lectures, seminars, workshops, and exercises. Students are assessed separately through oral or written exams. In the projects, students collaborate in small teams, typically 4–5 students, to deal with complex real-life problems, apply theory to practice, and develop problem-solving and collaborative skills [52]. The students themselves manage their collaboration, project progress, and time allocation. Within the thematic framework of each semester, they are free to select project topics, the roles of team members, and essential elements of learning. Supervisors act as facilitators and provide students with feedback on their progress through weekly or biweekly meetings. By the end of the semester, every student attend a group-based project exam which is mainly assessed based on individual performance at the exam [52].

AAU recruits over 2400 international students each year into its ordinary programs, part-time programs, foundation courses, and visiting students' programs [53]. Most international students are enrolled in ordinary two-year master's programs. Only two ordinary bachelor programs at AAU recruit international students: 1) chemical engineering and 2) applied industrial engineering.

Due to the international orientation of some engineering departments, students are administratively placed in intercultural teams or encouraged to work on their semester projects with peers from different cultural backgrounds [48]. As a result, they learn to work across cultures; behave, think, and communicate appropriately in intercultural settings; and acquire experience with international collaboration [16].

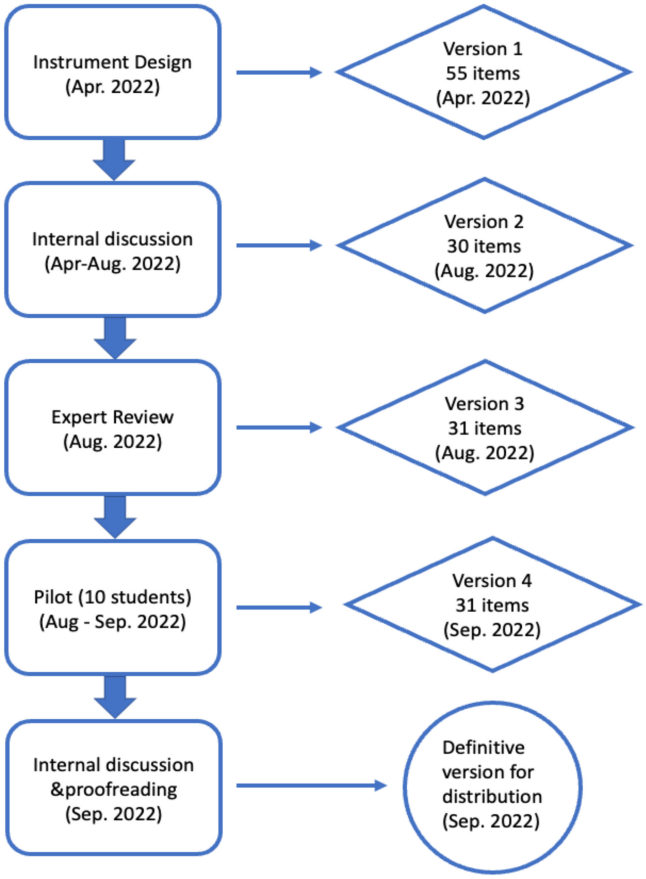

Fig. 3. Flowchart of the instrument design and validation process.

B. Procedures of Instrument Design

Our survey instrument was developed using an integrated approach that included both inductive and deductive techniques. The theory and literature studies were carried out first, followed by qualitative narrative interviews. The theoretical framework served as an initial background to develop items, and an initial pool with 55 items was proposed in the first round. Fig. 3 shows the procedures and timeline followed to design and validate the instrument before its distribution, and the steps are elaborated in the next paragraphs.

The instrument was discussed in multiple rounds by all authors from April 2022 to August 2022. Twenty-five irrelevant and redundant items were removed. Thirty items were sent to three experts for content validation in August 2022. The items with unclear meaning were changed and one item related to online resources was added. Then, ten students (six local and four international) were invited to take part in the pilot study. The grammatical subject and sequence of items were subsequently revised. Four international students commented on the revised instrument and confirmed that the revised instrument adequately reflected their international teamwork experience.

Upon completing the pilot, the authors further discussed the instrument and agreed on a final version consisting of 31 items. The survey was then reviewed by an English native proofreader before it was considered ready for distribution.

The instrument included three sections. Section I collected the demographic data of respondents. Section II comprised 31 items with a 5-point Likert scale and guided by the following question: "Based on your recent experience in an international team project, in which ways have the following aspects been helpful to you to work in this environment?" Students were required to rate the items on a scale from 1 to 5, showing the extent of helpfulness, from not at all helpful to highly helpful. The survey ended with Section III, which had three open-ended questions that enabled the respondents to provide further comments on which item was the most or the least helpful.

C. Ethics and Administration

The study received ethical approval from the Institutional Review Boards (IRBs) of AAU and has been registered in the General Data Protection Regulation (UE) 2016/679 GDPR. Before filling out the instrument, participants were informed that their participation was entirely voluntary, and they were required to give their consent by signing a consent form or clicking on the consent button. All personal information was kept confidential and stored securely in the faculty's data management documents, with only the key researchers of this study having access.

D. Participants and Data Collection

The data were collected using both SurveyXact software and paper distribution at AAU. The survey link was first sent in mid-October 2022 to the study secretaries and program coordinators in all engineering and technology faculties offering international programs, such as architectural engineering, biotechnology, chemical engineering, civil engineering, electronic engineering, energy engineering, software engineering, and so on. Reminders were emailed to the same recipients at the beginning of November 2022. These secretaries and program coordinators in turn sent emails inviting 919 engineering students in the 2022/2023 academic year to participate in the survey. A total of 212 students completed the survey and gave their consent, representing a 23.2% response rate, of which 178 responses were valid. To increase the responses and balance the study program and gender, the survey was also distributed in-person by the first author to 151 students from various engineering fields in mid-November 2022. Among these, there were 132 valid responses. A total of 310 responses were thus considered for further analysis.

Table I presents the sample distribution according to several variables. Most respondents were at the graduate level, while data on undergraduates were collected from only two international programs. The sample was relatively representative in terms of gender, nationality, and level of experience with PBL.

E. Validity and Reliability

1) Construct Validity: Construct validity is concerned with the extent to which a set of indicators reflects a theoretical relationship that is not directly measurable [54]. An exploratory factor analysis (EFA) approach was taken to reduce the number of variables and uncover underlying structures or relationships

TABLE I
PARTICIPANTS' DEMOGRAPHIC DATA ($N = 310$)

Category	Frequency	Percent (%)
Gender		
Female	111	35.8
Male	197	63.5
Prefer not to say	2	0.7
Nationality		
Local students	134	43.2
International students	175	56.5
Not specified	1	0.3
Year of Study		
Undergraduate (first-, second- and third-year bachelor)	47	15.2
Graduate (first- and second-year master)	263	84.8
Type of PBL learner		
Beginner (Under 1 year)	113	36.5
Novice (1 – 3 years)	119	38.4
Experienced Learner (Over 3 years)	78	25.2

among the set of variables [55]. EFA can also contribute to the item revision and improve reliability and content validity [55]. Prior to the factor analysis, the Kasier–Meyer–Olkin (KMO) value analyzed using *IBM SPSS Statistics* version 28 was 0.827 and Bartlett's test of sphericity was significant (p<0.001), confirming that the respondent data were adequate for an EFA. Principal component analysis was used as the extraction method, with eigenvalues greater than 1.00. The varimax rotation technique was utilized to clarify the relationship among the factors. Items with a factor loading greater than 0.40 were retained, because a factor loading cutoff score of 0.40 or above is considered meaningful [56], [57].

Our EFA result suggests that five factors are best explained by the covariation matrix. The factor loading result is listed in Table II. Five items were removed because their factor loading values were below 0.4. In light of this, they did not fit into any of these five factors. No cross-loading items were found in the result, meaning that each item corresponds strongly to a particular construct. The number of retained items loaded on each factor is shown in Table III. These five factors reflect key elements of three dimensions in our theoretical framework. Their relations are also shown in this table.

2) Reliability: The internal consistency coefficients for each factor in the sample ($N = 310$) were also calculated through Cronbach's alpha. The overall value for the scale was found to be 0.841, which demonstrates the good reliability of this survey ($\alpha > 0.80$) [58]. The values for each subscale are shown in Table II; these range from 0.65 to 0.81, meaning each has at least a moderate level of reliability for a survey in the explorative stage [58], [59], [60].

V. RESULTS

A. Descriptive Statistics

Descriptive statistics analysis was conducted for each factor using means and standard deviations, with the results shown in Table IV. Factor 1, IM, had the highest mean score ($M = 4.220$ and $SD = 0.662$), whereas Factor 5, ES, had the lowest ($M = 2.902$ and $SD = 0.905$). Meanwhile, a one-sample t-test was conducted to determine whether the mean of each factor was different from a test value of 3.00, which was the midpoint of our 5-point Likert scale. Significant differences (p<0.05) were shown in the factors of IM, SE, SB, and TD. This indicates that the students responded positively toward these factors (i.e., rating them "helpful" or "strongly helpful" on average). However, there was no statistical difference (p>0.05) between the ES factor and the test value, meaning the students' responses were considered neutral.

Additionally, Cohen's d value was utilized to measure the effect size of each factor. Among the four factors showing significant differences, IM had a large effect size [61], and this contributed most to students' agency development in an intercultural PBL team setting, followed by TD. The relatively small effect size of SE and SB showed that some survey items within these two factors could be further tested.

Table V shows the students' responses and the means and standard deviation for each item. For the IM factor, students perceived that all items supported their agency development. Based on means and response rates, IM 3 was the most supported statement in this factor. Within the SE factor, the most important item to build agency was students' ability to work with members from different backgrounds (SE 5). However, roughly 60% of students reported that their knowledge of team members' backgrounds (SE 1) and prior experience (SE 3) weakly contributed to their agency development. For the SB factor, the mean scores of all items were between 3.390 and 3.671, indicating that students viewed these items as supportive for agency development, with team plan execution receiving the highest score (SB 3). The analysis of the TD factor indicated that all items were recognized by students as essential to developing their agency, from the highest ranked item (referring to plan adjustment, TD 4) to the lowest (resolution of unexpected issues, TD1). Within the factor of external support, students gave the most positive responses to the item concerning resources from their study programs (ES 3). In contrast, the students indicated that the help from both their supervisors (ES 1) and the university (ES 4) made a limited contribution to their agency building in an international team, while online resources (ES 2) contributed the least.

B. Analysis of Demographic Variables

As suggested by [62], a t-test and analysis of variance (ANOVA) were applied to measure the statistical significance of several independent variables within these five factors. In this study, each independent-samples t-test compared the means of two independent groups, divided by gender, year of study (undergraduates and graduates), or nationality (locals and internationals). Meanwhile, the ANOVA compared the variances across the means of the three experience categories of PBL learner.

Gender: The result in Table VI showed that the factors IM and SB had significant differences. Therefore, students of different genders had different perceptions of the extent to which motivation and self-regulated behaviors in teams support their agency development. Comparatively, Cohen's d value of IM was higher than that of SB, indicating that between the male and female students, engineering students' agency

TABLE II
RESULTS OF THE EFA

Factor/Subscale	Item	Factor loading	Cronbach's α
Factor 1 Interest and motivation (IM)	IM 1 Working in an international team interests me	0.722	0.715
	IM 2 I welcome the diversity inherent in working in an international team.	0.700	
	IM 3 I believe my international team experience could prepare me for future work in a global context.	0.670	
	IM 4 In my international team, I am motivated to explore problems in a global context.	0.593	
Factor 2 Self-efficacy (SE)	SE 1 I have knowledge about my team members' background at the project start.	0.633	0.651
	SE 2 I know what it takes to work in an international team.	0.587	
	SE 3 I have prior experience of working in an international team.	0.528	
	SE 4 I am confident in my ability to overcome challenges in my international team	0.502	
	SE 5 I am capable of working with people from different backgrounds.	0.495	
	SE 6 I am able to take initiatives throughout the process of working on the project with my international team.	0.459	
Factor 3 Self-regulated behaviors in teams (SB)	SB 1 In my international team, we set up common learning goals at the project start.	0.788	0.760
	SB 2 We make plans according to our learning goals in my international team.	0.784	
	SB 3 We regularly check up on the team plans to ensure they have been followed.	0.626	
	SB 4 We self-evaluate our project process according to our learning goals.	0.571	
	SB 5 We adopt time management strategies to organize projects.	0.527	
Factor 4 Team dynamics (TD)	TD 1 In case of unexpected issues, we meet together immediately to discuss solutions.	0.695	0.808
	TD 2 We provide constructive feedback to each other.	0.674	
	TD 3 My team encourages each member to speak out.	0.667	
	TD 4 We adjust our plans according to the project process.	0.661	
	TD 5 My team makes efforts to constructively handle team conflicts.	0.648	
	TD 6 We support each other so no one lags behind.	0.617	
	TD 7 My team encourages diverse individual opinions in our project.	0.535	
Factor 5 External support (ES)	ES 1 We are guided by our project supervisor regarding how to work in an international team.	0.676	0.658
	ES 2 We use online resources (e.g. YouTube, online courses) to learn more about how to work in an international setting.	0.656	
	ES 3 We are offered training activities organized by the university/faculty on how to work in an international team.	0.637	
	ES 4 We are provided needed resources (e.g. materials, facilities) for our international project teamwork to function from our study program.	0.598	
Removed items	1. We meet regularly to work together on the project. 2. My international team is formed by common interests in the project topic. 3. We work on project tasks which are distributed by individual strengths. 4. We take turns to serve as team leaders. 5. We make efforts to improve our communication skills in an international team.		

TABLE III
CORRESPONDING DIMENSION AND ITEM NUMBERS FOR FACTORS

Dimension	Factor/Subscale	Number of items
Intrapersonal	Factor 1 - IM	4
	Factor 2 - SE	6
Behavioral	Factor 3 - SB	5
Environmental	Factor 4 - TD	7
	Factor 5 - ES	4
In total		26

TABLE IV
RESPONSES AND SOME DESCRIPTIVE STATISTICS OF THE ITEMS ($N = 310$)

Factor	Mean	Standard Deviation (SD)	t	Sig. (2-tailed)	d
IM	4.2202	.662	32.468	<0.001	0.788
SE	3.6812	.619	19.393	<0.001	0.028
SB	3.4961	.802	10.898	<0.001	0.253
TD	4.0162	.627	28.514	<0.001	0.506
ES	2.9019	.905	-1.908	0.57	-
Total	3.6988	.473	26.011	<0.001	-

building was supported more by interest and motivation than by self-regulated behaviors in teams.

The results also reveal that the mean scores of female students in IM and SB were higher than those of male students, suggesting that the female students in this study placed more importance on interest and motivation and on self-regulated team behaviors as their sources of agency.

Nationality: In Table VII, four factors: 1) IM; 2) SE; 3) SB; and 4) ES—showed statistically significant differences on nationality. Therefore, the students' nationality was relevant to their perceived level of motivation, self-efficacy, self-regulated team learning, and external support. Factor IM had the highest Cohen's d value, indicating that students from different national groups perceived that their interest and motivation contribute the most to their agency building.

The mean scores of local students and international students were also compared. As shown in Table VII, international students scored higher than local students in four factors with significant differences, meaning that students from outside Denmark reported a higher level of importance on most of the factors than the local students.

Year of Study: In Table VIII, a significant difference in the IM factor illustrated that engineering students' grade level correlated with their perceptions of interest and motivation. Furthermore, the mean score of the undergraduate students was higher than that of graduate students, showing that the undergraduates had higher perceptions than the graduates concerning the importance of interest and motivation in international team agency building.

TABLE V
RESPONSES AND SOME DESCRIPTIVE STATISTICS OF ITEMS ($N = 310$)

Item	Responses rate in each score (%)					Mean	SD
	1	2	3	4	5		
IM							
IM 1	2.3	3.5	16.5	36.5	41.3	4.110	.956
IM 2	.3	2.3	10.0	31.9	55.5	4.400	.785
IM 3	.6	-	11.6	24.8	62.9	4.494	.749
IM 4	3.2	8.1	21.0	33.2	34.5	3.878	1.075
SE							
SE 1	16.5	15.2	27.7	29.7	11.0	3.035	1.245
SE 2	1.6	7.7	25.2	39.7	25.8	3.803	.964
SE 3	31.0	14.8	15.5	18.7	20.0	2.820	1.533
SE 4	1.0	4.2	16.8	48.1	30.0	4.020	.851
SE 5	-	2.9	7.4	38.7	51.0	4.378	.748
SE 6	1.3	4.2	16.8	45.5	32.3	4.032	.881
SB							
SB 1	5.8	16.1	27.7	32.3	18.1	3.407	1.130
SB 2	5.8	18.4	23.5	33.9	18.4	3.407	1.153
SB 3	2.9	9.4	28.1	37.1	22.6	3.671	1.018
SB 4	6.5	14.5	31.0	29.7	18.4	3.390	1.135
SB 5	6.5	13.2	20.6	35.2	25.2	3.607	1.166
TD							
TD 1	2.3	8.1	23.2	32.3	34.2	3.881	1.044
TD 2	2.6	5.8	20.6	41.6	29.4	3.894	.978
TD 3	.3	6.1	16.1	40.3	37.1	4.077	.896
TD 4	-	.6	11.0	39.4	49.0	4.368	.702
TD 5	1.9	5.2	22.6	41.3	29.0	3.903	.944
TD 6	1.6	6.8	19.4	42.6	29.7	3.912	.950
TD 7	.3	6.1	16.5	40.3	36.8	4.071	.897
ES							
ES 1	17.7	21.0	23.5	23.5	14.2	2.955	1.314
ES 2	44.2	17.4	12.3	11.6	14.5	2.350	1.490
ES 3	30.0	23.5	23.5	15.8	7.1	2.464	1.263
ES 4	1.6	10.3	23.2	32.3	32.6	3.839	1.046

TABLE VI
GENDER VARIATION ($N = 308$)

Factor	Gender*	Mean	SD	t	Sig. (2-tailed)	d
IM	M	4.151	.676	-3.007	.003	0.342
	F	4.365	.573			
SE	M	3.698	.575	.651	.516	-
	F	3.650	.691			
SB	M	3.420	.771	-2.390	.017	0.281
	F	3.645	.828			
TD	M	3.984	.604	-1.196	.232	-
	F	4.073	.671			
ES	M	2.873	.904	-.857	.392	-
	F	2.965	.896			
Total	M	3.664	.470	-1.873	.062	-
	F	3.768	.464			

** M – Male students (N=197); F- Female students (N=111)*

Type of PBL Learner: In Table IX, significant differences were found in the factors IM, SB, and ES. This means that PBL learner experience levels were correlated with engineering students' perceptions of interest and motivation, self-regulated team-based behaviors, and external support. Furthermore, the effect size was measured through Eta-squared (η^2) in ANOVA [62]. Of these three factors, IM had the largest effect size, meaning that different types of PBL learners perceived the factor of interest and motivation to be the most important to their agency development in intercultural PBL teams.

Post hoc tests with ANOVA using both the Bonferroni and the Tamhane statistics were applied to explore the differences of means among IM, SB, and ES. PBL beginners perceived that interest and motivation supported their agency development more than the two more experienced groups. In both the SB and ES factors, the correlation is only shown between PBL beginners and experienced learners. PBL beginners perceived more than PBL experienced learners that self-regulated team

TABLE VII
NATIONALITY VARIATION ($N = 309$)

Factor	Nationality*	Mean	SD	t	Sig. (2-tailed)	d
IM	L	3.944	.733	-6.611	<0.001	0.776
	I	4.434	.511			
SE	L	3.582	.604	-2.400	.017	0.277
	I	3.751	.616			
SB	L	3.251	.775	-4.909	<0.001	0.563
	I	3.687	.773			
TD	L	2.560	.808	-.292	.770	-
	I	3.165	.892			
ES	L	4.010	.586	-6.153	<0.001	0.031
	I	4.029	.656			
Total	L	3.531	.458	-5.737	<0.001	-
	I	3.828	.446			

** L- Local students (N=134); I – International students (N=175)*

TABLE VIII
VARIATION IN YEAR OF STUDY ($N = 310$)

Factor	Year of Study*	Mean	SD	t	Sig. (2-tailed)
IM	U	4.426	.448	3.107	.003
	G	4.184	.687		
SE	U	3.741	.692	.721	.471
	G	3.671	.605		
SB	U	3.630	.749	1.242	.215
	G	3.472	.810		
TD	U	4.003	.738	-.155	.877
	G	4.019	.607		
ES	U	2.899	.893	-.024	.981
	G	2.902	.909		
Total	U	3.766	.463	1.057	.291
	G	3.687	.475		

** U- Undergraduate students (N=47); G - Graduate students (N=263)*

TABLE IX
ANOVA BASED ON TYPE OF PBL LEARNERS ($N = 310$)

Factor	Type*1	Mean	SD	F	Sig. (2-tailed)	η^2	Post hoc result*2
IM	A	4.400	.527	11.138	<0.001	.068	A>C (p<0.001) A>B (p=0.043)
	B	4.223	.606				
	C	3.955	.820				
SE	A	3.625	.609	.737	.480	-	-
	B	3.707	.621				
	C	3.722	.631				
SB	A	3.614	.783	3.259	.040		A>C (p=0.034)
	B	3.503	.816				
	C	3.315	.783				
TD	A	3.928	.689	2.433	.089	-	-
	B	4.108	.606				
	C	4.004	.550				
ES	A	3.094	.933	4.264	.015	.027	A>C (p=0.025)
	B	2.824	.889				
	C	2.744	.850				

**1 A- Beginner (N=113); B-Novice (N=119); C- Experienced Learners (N=78)*
**2 Results with no significant differences are removed*

learning and external support played an important role in their agency development.

VI. Discussion and Conclusion

This study explored which elements engineering students consider important in supporting their development of learner agency in an intercultural PBL team setting. A theoretical framework with three interrelated dimensions of learner agency (intrapersonal, behavioral, and environmental) was established to serve as a foundation for the survey instrument development. Based on an EFA of the responses from 310 engineering students, a five-factor structure was validated and identified, including 26 items as the best model fit for the data. These five factors consisted of: 1) interest and motivation; 2) self-efficacy; 3) self-regulated behaviors in teams; 4) team dynamic; and 5) external support.

Out of these five factors, the mean score of Factor 1, Interest and motivation, was the highest, whereas that of Factor 5, External support, was the lowest. It also indicates that students rely on internal sources for agency development more than external factors. This is a positive indicator showing that the engineering students themselves are proactive in intercultural PBL team settings, in line with prior studies emphasizing the importance of personal autonomy in both PBL and intercultural learning [63], [64].

Furthermore, these five factors corresponded to our proposed framework on learner agency. To be more specific, Factor 1, interest and motivation, and Factor 2, self-efficacy, reflect the intrapersonal dimension, which is consistent with prior studies treating motivation and self-efficacy beliefs as the most crucial personal values in agency development [10], [30], [45], [65]. Based on the data analysis, engineering students showed positive attitudes to both factors, with interest and motivation playing a more significant role in building agency in an intercultural PBL team. Most items in these two factors were seen as helpful to build agency by at least 60% of respondents, with prior experience in international PBL teams and knowledge of team members' backgrounds as the only exceptions.

Factor 3, self-regulated behaviors in teams, is associated with the behavioral dimension, which is in line with some researchers' highlighting of the importance of self-regulation in learner agency [1], [2], [23], [47]. According to Bandura [11], [23], the core components of self-regulated learning include goal setting, planning, monitoring, and reflecting and evaluating. The results suggest that, in general, engineering students in an intercultural PBL environment perceive the items relating to these four elements as essential, and their mean scores were likewise relatively high.

Factor 4, team dynamics, and Factor 5, external support, are associated with the environmental dimension of agency. Prior research has recognized both relational and situational sources of agency, such as trust building, team dynamics, peer support, external help from supervisors, and other external support (e.g., the program and institution) [10], [29], [30], [49]. Based on students' responses, they perceived team dynamics as significant for their agency development in intercultural PBL teams. However, within external support, institutional support was recognized as a helpful resource by engineering students, while supervisor support, online resources, and other materials made limited contributions to agency development. Students' positive attitude toward institutions differs from our qualitative findings, which indicated that institutions did not provide much support for students in adapting to the intercultural PBL environment [21]. Hence, the item regarding institutional support (ES 3) could be considered for further investigation and revision in the future studies.

To answer the second research question, several demographic variables, including gender, nationality, year of study, and level of experience with PBL, were identified as relevant to engineering students' agency development in an intercultural PBL team. Significant differences between genders were found within Factor 1 and Factor 3, with female students assigning more significance than male students to both factors in developing their learner agency in intercultural PBL teams. This result is consistent with a prior study, in which female students were found to be more comfortable with differences and had better intercultural interactions than male students in a culturally mixed team [40], [41]. Statistical differences between nationalities were significant for all factors other than team dynamics. Both local and international students believed that their own interest in and motivation for both PBL and interculturality contributed the most to their agency development, followed by self-efficacy, external support, and self-regulated team behaviors. However, the importance of all four factors was perceived as higher by international students than local students. Regarding students' year of study, there was only a significant difference in Factor 1, with undergraduate students assigning this factor greater importance than graduate students. The result from the ANOVA test indicated significant differences between PBL experience level groups on Factor 1, Factor 3, and Factor 5. Through post hoc test analysis, PBL beginners were found to assign the highest perceived importance to interest and motivation, self-regulated team behaviors, and external support.

These results lead to several practical implications. First, engineering students should develop self-awareness in agency building, which empowers them to develop more effective learning strategies in the PBL and intercultural environment. Second, it is important for engineering educators and program organizers to be more mindful of the needs and experiences of certain groups, such as PBL beginners, female students, international students, and undergraduates in their PBL implementation and curriculum design. They should also provide customized resources to support engineering students' intercultural competencies and cross-cultural interactions in PBL teams. Third, it is essential that learning institutions provide more on-campus activities to encourage engineering students' intercultural awareness development and increase the support students receive from working in intercultural teams.

However, the results are also subject to several limitations. First, the study is explorative, with a limited number of participants ($N = 310$) representing only a single institution. Therefore, the outcomes should be further validated with larger

populations representing other PBL institutions and even non-PBL contexts. Second, the reliability of some factors (Factors 2 and 5) remains moderate (α <0.70), suggesting that the result of this study shall be further tested. Third, this study did not include the qualitative responses for open-ended questions from the participants, which would have allowed us to further contextualize our findings. However, students' response rates to these questions were quite low (less than 30%) and most responses consisted of only one or two short keywords without explaining how these items were important. Fourth, the results identified certain patterns via demographic analysis, such as differences in gender and year of study. These results are limited due to the small sample size of female students and undergraduates. While the study explored students' self-reported perceptions, the results should be further compared by other sources of data, such as follow-up interviews and observations, as well as taken from participants who are educators. Comparative studies between different institutions or student groups can also be done in the future, using different quantitative statistical analyses.

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