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Gaps between reflection frameworks and students' practice: implications for design education

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Abstract

This paper aims to identify gaps between the reflection frameworks and students' practice. Through a systematic literature review (PRISMA) and a qualitative survey of students, 12 reflection frameworks were reviewed, and the 13 challenges students faced at design projects in two design schools were identified. The results indicate three gaps between theory and students' practice: skills of designers, granularities of reflection items, and supports of bridging reflection to next actions. This study provides insights for future development of support tools to bridge the gaps in design education.

Keywords: design guidelines, engineering design, reflection, systematic review

1. Introduction

The design process is a sequence of iterative activities, and it is essential to keep learning and improving the process. As Schön describes (e.g., Schön (1983), (1987)), reflective practice is a core of the design process. Although reflection is essential in design practice, Baumer et al. (2014) and Bentvelzen et al. (2022) mentioned a lack of conceptual agreement on the definition of reflection through their systematic reviews. On the other hand, many studies discuss reflection or reflexivity and propose models or frameworks individually. Developing a synthesised model or framework is required to provide practical support for practitioners.

Reflection is often discussed in the context of learning and teaching. While several papers claim the educational benefit of reflection, students cannot incorporate reflection effectively in design projects. Since design teams face various dilemmas (Hölzle & Rhinow, 2019) or bottlenecks (Rekonen & Hassi, 2018), students new to studying design face many difficulties that might hinder them from acquiring design methods, mindsets, and skills. In terms of this point, introducing support for reflection would be helpful to ensure effective learning from project practice. Then, what kinds of support are needed to develop and provide for students?

This research aims to identify the gap between the frameworks proposed in papers and the situations students face in practice to provide support which enhances learning and improves team processes. This paper answers the following questions: 1) What are the aims and items of the reflection frameworks proposed in the existing literature? 2) What kinds of perspectives do students find challenging and need to be included in the frameworks?

This paper defines reflection as "*a discursive process of articulating, sharing, and negotiating individual experiences of project issues within project teams to reach a collective understanding of the experienced issues and draw conclusions for further actions*" based on Hartmann et al. (2023).

This paper is structured as follows: We first describe our methodological approach. Section 2 presents the approach to systematically reviewing the literature (PRISMA). Section 3 presents our methodology to survey the challenges students face. We then describe the results of our literature review and qualitative survey in Section 4. Finally, we discuss the implementation of results and recommendations for further research.

2. Systematic review

To gain a comprehensive understanding and provide a basis for discussion of the reflection frameworks, we conducted a systematic review of literature dealing with reflection frameworks, following the PRISMA approach (Page et al., 2021). The term "*(reflection) framework*" means a supporting structure that includes sets of questions or a canvas that indicates procedure. The flow of the systematic review is shown in Figure 1. This study searched literature using an electronic bibliographic database, Scopus. The search was limited to journal articles or conference papers published in English ((LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp")) AND (LIMIT-TO (LANGUAGE, "English"))). We broadly searched the literature without limiting it to well-known journals to include various frameworks. Search terms were chosen to include not only reflection itself but also reflexivity, reflective practices and attitudes in practice (TITLE ("reflection" OR "reflective" OR "reflexive" OR "reflexivity")). In total, 122,337 publishments were identified. 467 contained phrases related to the design, as shown in Table 1. In order to broaden the dataset of candidate papers, four relevant publications identified via other methods were included. The first author conducted all processes.

Table 1. Search terms

***Topic* AND**	***Context* AND**		Document Type	Language
reflection OR	design thinking OR	product design OR	Conference paper OR	English
reflective OR	design project OR	service development OR	Article OR	
reflexivity OR	engineering project OR	product development OR		
reflexive OR	service design OR	concept design OR		

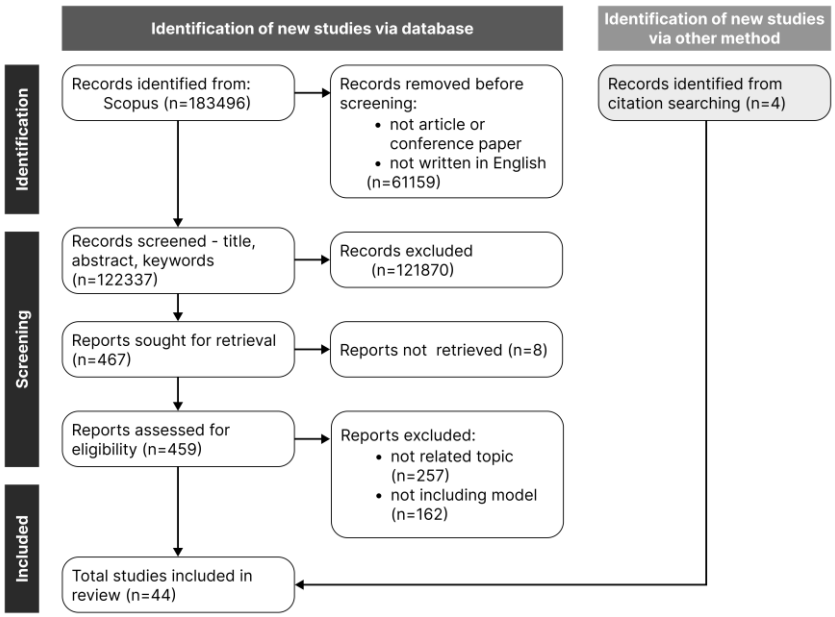

Figure 1. PRISMA diagram for systematic review (based on Page et al. (2021))

Table 2 shows the inclusion criteria used in this study. The first criterion relates to the use of terminology. Terms such as "reflection" have various meanings and are used in many contexts, so we exclude publishments in different contexts, for instance, in the fields of light, waves, or computers. When the terms did not refer to the design activities, e.g., part of a research methodology,

publishments were also excluded. Another relates to the proposal of frameworks. Since this study aims to deepen the understanding of the reflection frameworks proposed in the existing research and provide a basis for discussion, papers that did not include a framework were excluded. For example, articles that did not show models and frameworks related to reflection or questions for reflection were excluded. Finally, 44 papers in total were included in this review.
For the literature analysis obtained, papers were classified with the following steps. First, articles were determined whether they proposed a new framework or cited from the literature. Second, classification was conducted to identify whether models provide concrete items or philosophical models.
Further analysis was conducted only on the frameworks. Using the model shown in Figure 2, frameworks were classified according to the stages they included. This model was proposed by Ammersdörfer et al. (2022). They combine the three-stage model (*Reflecting*, *Planning*, *Adapting*) by West M.A. (2000) and the model proposed by Jobst et al. (2020), reflection components (*Awareness* and *Analyzing)*. In *Reflecting*, current goals, performance, and strategies are evaluated. *Awareness* includes three elements (*knowledge*, *motivation*, and *expectation*) and is used in the evaluation. Next, practitioners analyse the situation in three dimensions (*social*, *process*, and *goal*) and consider alternatives to tasks and problems (*Analyzing*). In *Planning*, the team determines alternative actions and options. In *Adapting*, changes and actions agreed upon previously are implemented before restarting the cycle.

Table 2. Inclusion criteria

1	The words refer to a part of design activities. The words are not used in light, wave or computer fields. The terms do not refer to considerations of past events and experiences or as a part of research methodology.
2	Concrete frameworks for reflection (e.g., frameworks, models, or sets of questions) are included in the publication.

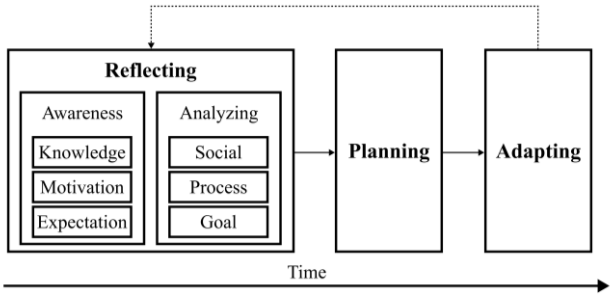

Figure 2. Reflection procedure based on Ammersdörfer et al. (2022)

After classification based on the model shown in Figure 2, open coding was conducted to categorise items proposed in the frameworks. The first author conducted all these processes, and the categories were finalised after discussing the results with the co-authors.

3. Qualitative survey

To identify the challenges in students' practice, students with experience participating in long-term design projects were targeted. In case 1, semi-structured interviews were conducted with the 25 students who participated in five months of design Project A. In case 2, a workshop was conducted. 6 students who experienced six months of Project B participated in the workshop. In the following section, we present the details of each survey.

3.1. Case 1: Project A (in Japan)

The participants were students with experience in the design project held at a Japanese university. This project took five months and aimed to develop a new product with a user-centred approach. Teams consisted of five or six people and included graduate students in engineering and third-year undergraduate students in art or other majors. This project was influenced by Stanford's ME310

(Carleton & Leifer, 2009). Different open-ended design brief was given to each team by their partner company. Teams conducted design activities such as user interviewing, prototyping, or testing. Since teams were not given detailed requirements, teams had to define problems through interviewing, identifying needs, or interpreting users.

Semi-structured interviews were conducted after the end of the project. Twenty-five students from six out of eleven teams consented to participate in this survey. The first author conducted all interviews, which lasted approximately one and a half hours and recorded them for analysis. The main questions are shown in Table 3. Participants were asked to explain the evolution of the product until the final and the situation within the team.

All dialogues were transcribed, and content analysis was conducted following the inductive content analysis approach proposed by Mayring (2021). First, the transcribed content was read several times to understand the data before analysing it. All documents were checked, and relevant parts were extracted—the analysis aimed to identify the challenges in the design project. The next step was the coding process for the extracted sentences. The sentences were interpreted and conceptualised one by one regarding the content of the challenges. A new category was generated if the concept did not fit into an existing category. When the category included various concepts, subcategories were generated. These processes were repeated, checking the structure of the categories, and coding proceeded, modifying definitions and levels of abstraction. After all documents were coded, the structure was rechecked and corrected with the co-author. The content analysis was finished when an agreement between researchers was made.

Table 3. General information about the project and survey

		Project A	**Project B**
Context	*Duration*	Five months	Six months
	Participants	Engineering graduated students Bachelor 3rd art students	Engineering Bachelor 1st students
Survey	*Method*	Semi-structured interview	Workshop
	Number	n = 25	n = 6
	Objectives	Understand the procedure and situation of each team faced	Identify the challenging moment in the project
	Main Questions	What did you conduct in the process of developing the product? How was the communication, atmosphere, decision-making or management of the team?	What did you find challenging in the project? What was the most critical and difficult to solve?
	Analysis	Inductive content analysis	KJ method

3.2. Case 2: Project B (in the UK)

Participants in this case were students who had experience in the design project held at the university in the UK. This project took six months and aimed at making a product that works for people in a real-life context with a contextual and human-centred approach. The teams consisted of four students; all were first-year undergraduate engineering students. Students learn practical skills such as conducting user research, representing research findings and considering human factors. All teams were given the same design brief and worked on user research, translating research into insights and concepts and developing a physical product. The brief was open-ended and indicated any detailed requirements.

The workshop was conducted after the end of the project. Six agreed to participate in the workshop. The online whiteboard tool Miro was used with stimuli to aid in recalling the experiences; seven categories and various relevant keywords were given. Seven categories included the four stages of the Double Diamond (*Discover*, *Define*, *Develop*, *Deliver*) (c.f., Design Council) and three additional categories (*Project*, *Team*, *Individual*). Relevant keywords were given, e.g., empathy, framing, ideation, conflict, mindset, etc. Participants recalled their experience in the project, defined the challenge's title, and wrote it with a detailed description. Each participant wrote ten challenges on average, and we got 61 challenges in total. The challenges were coded based on the categories

obtained through the analysis of Case 1 following the KJ method (Kawakita, 1991). New categories were created if concepts were not classified into the existing categories. The analysis results of each case were synthesised, and the categories of challenges were obtained.

4. Results

4.1. Results from systematic reviewing

This section presents results from analysing 44 publications collected from the screening process. Table 4 shows the classification of the publications analysed from two perspectives. Regarding the perspective of the *origin*, 5 include models proposed in the existing literature, 11 deal with models that combine several existing models, and 28 propose new models. In terms of the *level of abstraction* of the models, 23 show philosophical models describe the mechanism or system of reflection, 3 offer the flows or steps of reflection, 6 describe categories such as types or modes of reflection, and 12 present concrete items such as perspectives or questions for conducting reflection.

Table 4. Classification of models

Origin	*Citation*	*Combination*	*Proposal*	
n	5	11	28	
Level of Abstraction	*Philosophical*	*Flow or step*	*Category*	*Concrete items*
n	23	3	6	12

Table 5. Categorisation of frameworks (models including concrete items)

No.	***Author (year)***	***Origin***	***Stages***	***Doc. type***	***Context***	***Aim***
1	Broadway et al. (2003)	Combination	Organising Facts	cp	Engineering Design	Assessment of students
2	Pluskwik et al. (2022)	Combination	Awareness	cp	Education	Analysis of Student Learning Journals
3	Reymen et al. (2006)	Proposal	Awareness & Analyzing	ar	Design (Domain-independent)	Inventorying properties and factors
4	Davis et al. (2009)	Proposal	Awareness	cp	Engineering Design	Evaluation of design and reflective practice
5	Geis & Birkhofer (2009)	Proposal	Awareness	cp	(Engineering) Design	Ensure the quality
6	Tracey et al. (2014), Tracey & Hutchinson (2018)	Proposal	Awareness & Analyzing	ar	Design Thinking	Identity development
7	Razavian et al. (2016)	Proposal	Awareness	ar	Software Design	Ensure the quality
8	Jobst et al. (2020)	Proposal	Organising Facts	cp	Sketching and Prototyping	Facilitate the switch between visualisation and verbalisation
9	Inkermann et al. (2020)	Proposal	Reflecting & Planning	cp	Engineering Design, Product Development	Management of the product development process
10	Sanchez et al. (2022)	Proposal	Reflecting & Planning	cp	Engineering Design, Critical Reflection	Deepen learning and cultivate a mindset
11	Ammersdörfer et al. (2022)	Proposal	Reflecting & Planning	cp	Engineering Design	Define key characteristics of a management object

Table 5 shows the analysis results of 12 studies that provide concrete items. *Origin* is corresponding to Table 4. *Stages* is the results of classification based on the model shown in Figure 2. The framework that does not encourage analysing or evaluating the situation was classified as "*Organising Facts*". In the column, *Doc. Type* "cp" means conference paper while "ar" means articles. The last two columns show the frameworks' *Context* and *Aim*.

Since Tracey et al. (2014) and Tracey & Hutchinson (2018) described the same framework called "reflection prompt", these two are shown in the same row. Broadway et al. (2003) proposed *a "Skill-based Reflective Journal*" and showed a connection with the "*Affective/Associative Reflective Journal*" suggested by Blake & Blake (2003). Pluskwik et al. (2022) proposed a set of questions used in the Machine Learning analysis based on the existing theoretical framework. Other ten studies suggested new frameworks. Regarding stages, some frameworks only encourage organising facts (Broadway et al., 2003; Jobst et al., 2020). On the other hand, several frameworks (e.g., Inkermann et al., 2020; Sanchez et al., 2022) included questions to plan the following activities. While frameworks were mainly proposed in engineering design, their aims varied, including educational (evaluation of students, deepening learning) or practical (ensuring the quality, facilitating activity) aspects. The proposed items could be structured as encouraging to explain specific objects (product, team, individual, organisation, and activity) in each time series.

Table 6 shows the result of open coding for items in frameworks. The rows show the category of the contents on which items prompt reflection, and the columns show the stages in the reflection process. This table shows the number of items classified; subtotal numbers are written in bold style. Each item was classified into six categories, depending on the subject that prompted reflection: *Product*, *Design team*, *Individual*, *Organisation*, *Project*, and *Design Activity*. The contents are classified into the six *Stages* corresponding to Table 4 by adding two stages: a) *Organising Facts*, b) *Awareness*, c) *Analyzing*, d) *Planning*, e) *Defining Goal*, and *f) Feelings*. *Defining Goal* is not a planning activity but setting an ideal status, and *Feelings* represent the current feelings of the practitioner. 129 of 259 items are included in *Awareness* and *Analyzing* (*Reflecting*). Equally as many items (80 of 259) were classified as *Organising Facts*. Fewer (39 of 259) were categorised in *Planning* and *Defining Goal*. Eleven items were asked to describe *Feelings*.

Table 6. Analysis of concrete items of frameworks
(a. Organising Facts, b. Awareness, c. Analyzing, d. Planning, e. Defining Goal, f. Feelings)

	a	***b***	***c***	***d***	***e***	***f***	***sum***	**Definition / *Example items***
Product	**4**	**9**	**9**	**2**	**4**		**28**	**Focusing on products or their surroundings.**
Situation	2	2			1		5	*"What is the current state of the product being designed?"*
Results		3	3	2			8	*"What are consequences of the current state of the product?"*
Property	1	2	4	1			8	*"Are all factors taken into account in the design of the product being designed?"*
Others	1	2	2		3		7	*"What are desired properties of the product?"*
Design team	**6**	**4**	**25**	**7**	**2**		**44**	**Focusing on teams' collaborative work.**
Teamwork	1	2	16	5			24	*"What actions would improve your team's performance?"*
Member	1	1	2				4	*"Relative contributions of members"*
Relationship	2	1	4	2	1		10	*"How should communication be organized (information flow)?"*
Others	2		3		1		6	*"In what ways does your team's current performance hinder team success?"*
Individual	**14**	**13**	**7**	**5**	**1**	**10**	**50**	**Focusing on individual work.**
Work	2	1	3	3		1	10	*"How did the ways you've engaged in design affect the quality of your deliverables?"*
Skills	1	2	2	1		3	9	*"Where did you get the skills to handle the task?"*

Experience	4	2				1	7	*"How do you feel about the activity or experience in which you were engaged?"*
Others	7	8	2	1	1	5	24	*"What is your initial and immediate response to the activity or experience in which you were engaged?"*
Organisation	**9**	**2**	**2**				**13**	**Focusing on company or firm involved in.**
Vision	2	1					3	*"How does the company's vision influence the design task?"*
Constrain	3	1					4	*"What is the deadline of the design process?"*
Others	4		2				6	*"What are important competitors?"*
Project	**22**	**11**	**11**	**4**	**4**		**52**	**Focusing on process or context.**
Process	7	3	7	2	1		20	*"Which methods and strategies were helpful or less helpful?"*
Environment	4	1	2				7	*"How is the design process supported (machines, software, tools, secretary, room, methods, procedures, environment, etc.)?"*
Situation	3	2	1		1		7	*"What is the current state of the design process?"*
Others	8	5	1	2	2		18	*"What are possible trends in the design context?"*
Design Activity	**25**	**17**	**19**	**6**	**4**	**1**	**72**	**Focusing on tasks, approaches, and methods.**
Task	5	3	2	1	1		12	*"How explicit and clear were the tasks formulated?"*
Problem	3	4	3				10	*"What are the design problems? Which are the important problems that need to be solved? What does this problem mean?"*
Solution	2	4	2	1	1		10	*"What are the solution options? Can a solution option be compromised?"*
Decision Making	1	3	1				5	*"Can any constraints be relaxed when making a decision?"*
Approach	2	1	4	1			8	*"Analysis and assessment of method(s) & procedure"*
Others	12	2	7	3	2	1	27	*"What are the important stakeholders and their concerns?"*
Total	**80**	**56**	**73**	**24**	**15**	**11**	**259**	

This classification shows that the general structure of reflection frameworks consisted of representing process teams conducted, analysing and evaluating them, defining goals, and setting the next activity. As shown in example items, frameworks provided questions or prompts for reflection; however, many are vague, general, and context-independent. For example, some items instructed the practitioners only to analyse subjects or asked them to describe "problems", "properties", "tasks", "communication", etc., without any content limitation. Some frameworks only provided perspectives without concrete questions or prompts to implement reflection.

4.2. Results from qualitative survey

The results of the analysis of the data gathered through qualitative surveys are shown in Table 7. The *Definition* column describes what the issue relates to. For example, empathy and making appointments with target users were listed as relevant issues in *User Research*. Instances of statements referring to the category are given in the *Examples* column. In the interview, Project A participants explained situations in which they had difficulties and problematic moments they could recognise when they looked back at the interview. Students were able to explain the challenges they were facing by looking back and thinking objectively about events they did not know what the problems were at the time. Since Project B participants were first-year undergraduates, they faced challenges related to their skills. Otherwise, they explained similar challenges to students who participated in Project A.

Table 7. Categories, definitions, and examples of challenges

Category	Definition	Examples	A	B
Design Tasks	**Challenges related to specific design tasks, approaches, or methodologies.**			
User Research	Empathy, making appointments with target users	*"It was very difficult to find enough relevant users to interview."*	✔	✔
Problem Definition	Insight forming, data analysis	*"Narrowing the big problem into a valuable niche one is difficult."*	✔	✔
Ideation	Idea generation	*"We struggled with ideation."*	✔	✔
Testing	Get appropriate feedback	*"How to effectively receive and process feedback."*		✔
Management	**Challenges related to the management of process or project.**			
Scheduling	Time constraints, prioritising	*"Not enough time to conduct thorough testing."*	✔	✔
Iterative Improving	Planning, reflecting	*"Knowing when to change the route of your project completely."*	✔	✔
Team	**Challenges occur in a team or between members.**			
Conflict	Opposite opinion, culture, working style	*"It's kinda hard to negotiate with strangers for an introvert."*	✔	✔
Motivation	The way to encourage members	*"He said a demotivating word from the first day."*	✔	
Communication	Tools, frequency, language	*"My team was less responsive with online tools."*	✔	
Individual	**Challenges students found in their capabilities or works.**			
Skills	Tools, specific tasks (e.g., sketching testing, prototyping)	*"Difficult to translate ideas from our mind to paper."*		✔
Mindset	Against ambiguity or iterative process, fear of evaluation	*"I struggle with ambiguous projects or tasks."*	✔	✔
Environment	**Challenges related to the surroundings of the project.**			
Resource	Instruction, toolkit, material	*"Materials are not accessible (not in budget sometimes)."*		✔
Requirement	Design brief, partner company	*"The design brief was difficult, and we were distressed throughout the project."*	✔	✔

5. Discussion

This research aimed to identify the gap between the frameworks proposed in papers and the situations students face in practice to provide support to enhance learning and improve team processes. This research classified items of reflection frameworks and structured students' challenges. Results of the analysis on reflection items frameworks encourage organising facts.

The analysis identified three gaps between the frameworks and students' challenges. Firstly, there is a gap between the proposed way of reflection and students' reflection skills. In the existing frameworks, many encourage practitioners to organise teams' activities or to write down the status of designing products (Table 6). Some items asked practitioners to describe and answer the analysis results, such as "What are the problems arising in the process?". On the other hand, in the survey of students, some challenges only became apparent when looking back on them, or they struggled to identify problems such as "*Knowing when to change the route of your project completely.*" (Table 7). This shows that it is not easy for students working on a project to be aware of process issues, and more detailed guidance is required. Some items in the frameworks, such as organising facts and describing problems, tacitly assume well-established reflective skills and may not support practitioners who need a framework.

Secondly, there is a gap in scale between reflection items and students' challenges. The items included in the frameworks recommended reflection on a macro scale. For example, many items include comprehensive words such as products, properties, or processes and generally ask practitioners to

describe the current state, problems, and ideal state from those perspectives (e.g., 3, 9, 11 in Table 5). Some included micro-scale items; however, they only asked questions at each stage describing each task's outcomes (e.g., 8 in Table 5). On the other hand, the challenges students face are concrete. For instance, methodological issues in specific design tasks and process issues in concept selection. Although these are context-dependent and it is not easy to include them in frameworks, providing assessment policies or analysis perspectives could help address students' challenges.

Thirdly, there is a gap between the reflection stages and practice. In the frameworks, there were many items to facilitate the organisation, analysis and evaluation of facts. In comparison, there were few items on defining goals and planning future activities and very few to help implement the next cycle (Table 6). There were also several items in the analysis and evaluation, prompting without limiting the content or presenting a point of view (e.g., 1, 3, 6 in Table 5). On the other hand, while students were aware of the tasks they were conducting and their situation, they mentioned their unawareness of the problems and their lack of knowledge of how to improve them. In this respect, frameworks may not be helpful for students gaining skills or learning approaches.

These gaps between frameworks proposed in existing literature and students' challenges must be bridged. While reflection is a core design activity, it is difficult to implement for novice designers or those with little/no design experience. It was also clarified that specific support is required, not only to encourage reflection. Supports are needed to ensure that the problems are correctly identified and appropriate solutions are considered. Technology-aided tools are expected to be developed and introduced into practical situations in future research. For example, providing reflection materials through visualisation or AI-based activity data analysis during the project may be effective.

This study includes limitations in literature selection. We selected literature that contained words directly related to "reflection" in the title and discussed it in a design context. There may be further literature that provides insight. For example, studies focusing on user testing include reflective activities such as hypothesising, testing and planning for the next cycle. Although that kind of literature did not include words like "reflection", they may have been proposed models or frameworks related to reflective activity in design. This study synthesised models of reflection proposed in a design context and provided discussions for the development of supports.

6. Conclusion

This paper presented the results of a systematic review of reflection models and a qualitative survey of students. The review identified and categorised 44 publishments containing models, and concrete items of 12 studies were analysed. The analysis showed that there were as many items *Organising Facts* as *Reflecting* and fewer items classified as *Defining Goal* or *Planning*. Based on the survey of students, this paper pointed out three gaps between the models and the actual situation: skills of designers, granularities of reflection items, and supports of bridging reflection to the following actions. This study could be a starting point for developing support to bridge gaps in future research.

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