Chapter 2
Developing an Educational Innovation for Biophilic Design

Abstract Teaching students to practice biophilic design (BD) in an environmentally sustainable design (ESD) studio may enhance human–nature connectedness in their future design outcomes. However, integrating BD within ESD requires the development of a framework that is compatible with both approaches. Hence, a systematic teaching approach is critical to guide students in developing such a design framework. Reflective Action Conjecture Map (RACOM), an educational design approach for the ESD studio is developed that can guide educational designs to teach different sustainable design approaches. An educational innovation based on RACOM that facilitates students to develop BD frameworks is presented demonstrating the development process. This educational innovation aims to support students in overcoming three challenges: (1) shifting the sustainability view to derive common categorisations for criteria, (2) a systematic method to bridge ESD and BD, and (3) integrating the BD framework into the design thinking process. Three embodied educational design elements, namely, sustainability manifesto, success matrix and reflective portfolio are identified could support students to develop and use BD frameworks in sustainable designs.

2.1 Introduction

The previous chapter introduced a generic Reflective Action Conjecture Map (RACOM), an educational design approach for the ESD studio. Building on that approach, this chapter demonstrates how a RACOM for BD was systematically developed to support students in the development of a BD framework within a typical ESD studio. The RACOM for BD frameworks is presented first (see Fig. 2.1) followed by detailed descriptions of each component.

High-level conjecture is outlined by showcasing how a unique characteristic of the ESD studio and the identified challenges were used in the process. The three challenges are discussed pointing out the current debate on ESD studio education. A further mind-mapping exercise is shown (see Fig. 2.2) where the pedagogical

N. Wijesooriya et al., *A Biophilic Design Guide to Environmentally Sustainable Design Studios*, SpringerBriefs in Education,
https://doi.org/10.1007/978-981-19-4428-4_2

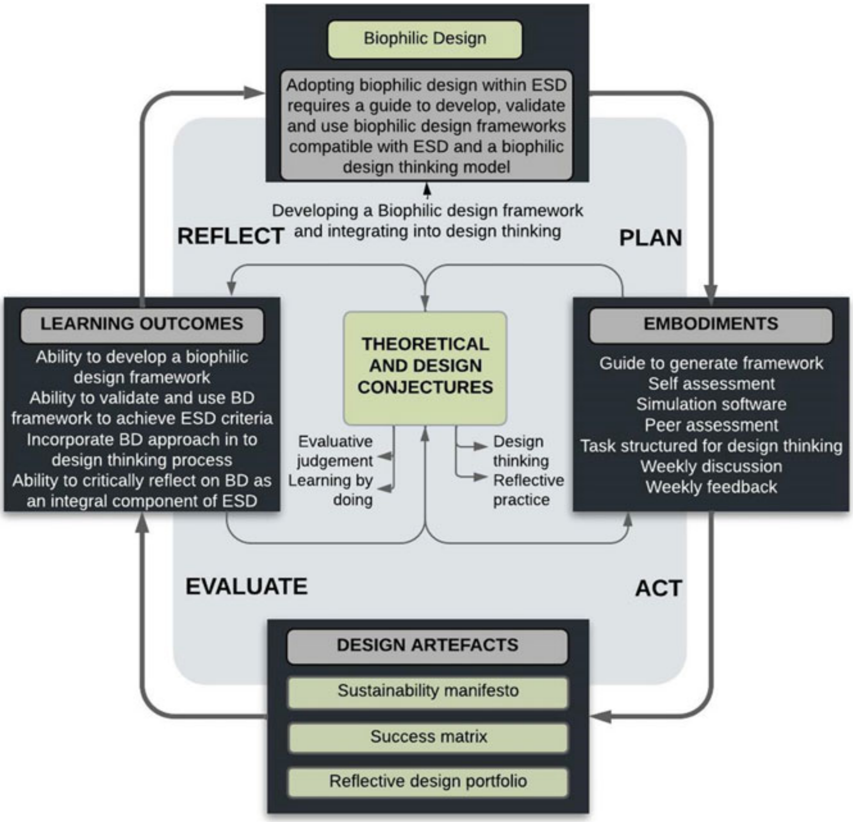

Fig. 2.1 A reflective action conjecture map for biophilic design frameworks

ideas that could potentially assist in overcoming the challenges are given. Thereafter the theoretical and design conjectures are outlined showcasing how they link embodiments, design artefacts and learning outcomes (see Fig. 2.3).

Each of the design artefact is detailed with a conjecture map showing how it can support to achieve learning outcomes through mediating learning processes. Finally, the develop process is shown in steps allowing the educators to replicate the same process for distinct purposes.

This chapter is intended for educators where the developed RACOM for BD frameworks can be directly adapted in a sustainable design studio.

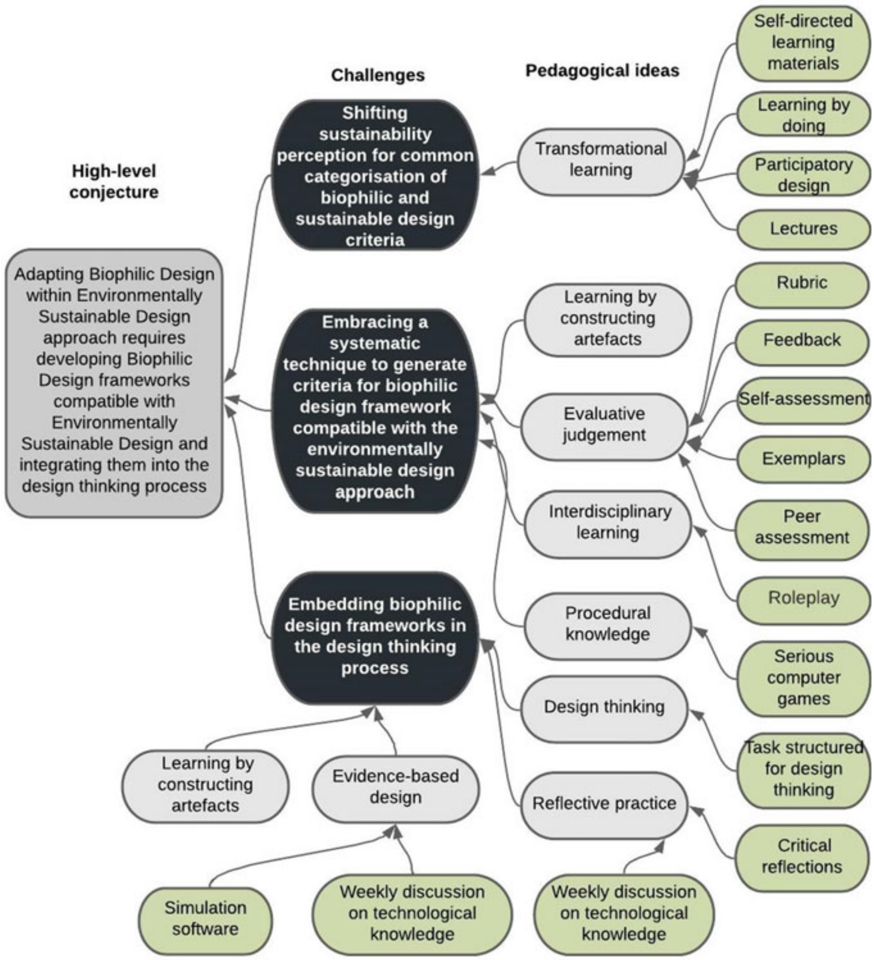

Fig. 2.2 Mind map deriving the high-level conjecture

2.2 A Reflective Action Conjecture Map for Biophilic Design

A Reflective Action Conjecture Map (RACOM) is an educational design approach that can be used in an environmentally sustainable design studio. RACOM can support educators in developing an educational innovation to teach various sustainable design approaches, such as energy-efficient design, passive solar design and biophilic design.

The development process for one such educational innovation is described in this chapter, and the RACOM development process for BD is described in Sect. 2.5.

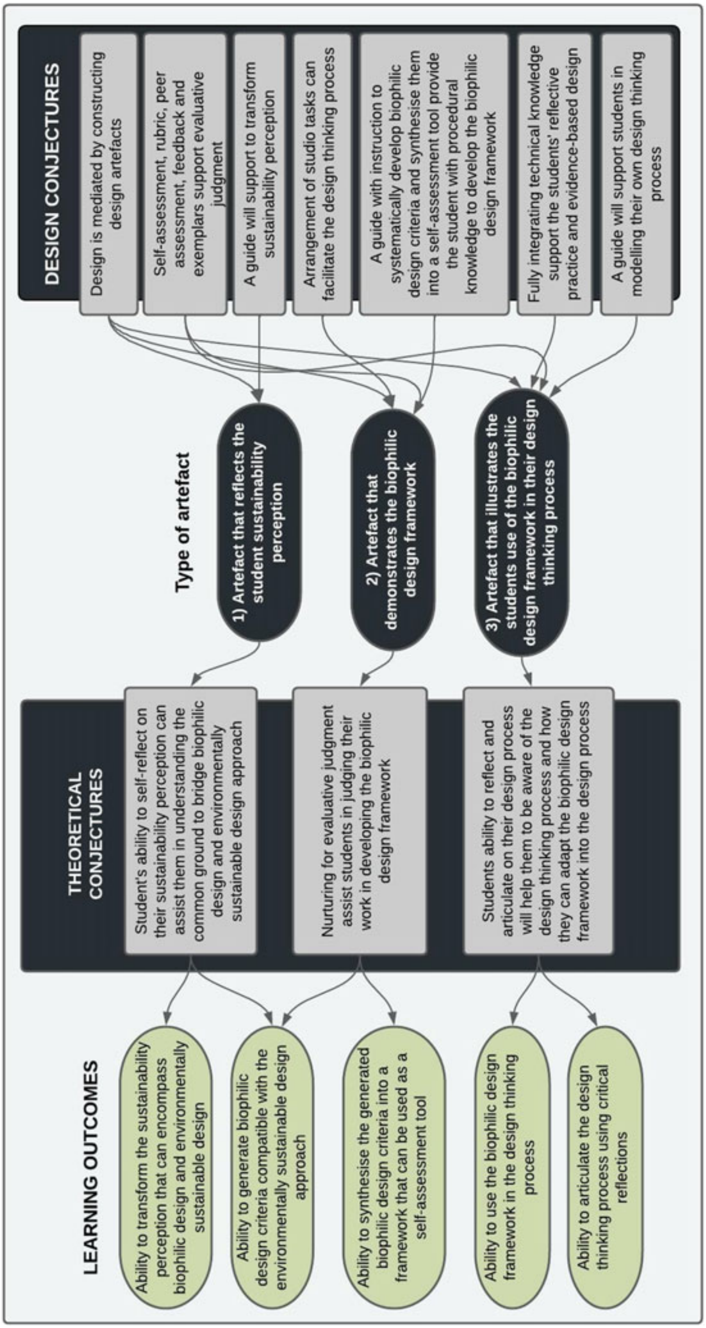

Fig. 2.3 Associating theoretical and design conjectures with design artefacts and learning outcomes

Using the abovementioned process, a RACOM for BD (Wijesooriya et al., 2020) was developed and implemented in an ESD studio. After evaluating the student responses and reflecting on the authors' experience in conducting the studio, the model was refined and further developed (Fig. 2.1).

As Fig. 2.1 illustrates, the RACOM for BD is focused on the BD framework development. This RACOM is a comprehensive model that includes all the pedagogical ideas that support students in developing BD frameworks and using them in a sustainable design studio. Educators can use the model by adapting its specific elements to suit their design studio project.

The high-level conjecture for BD framework development is discussed below to show how the different pedagogical ideas are connected to the key challenges. The theoretical and design conjectures are presented, highlighting their relevance in developing educational innovation. Mediating processes, learning outcomes and embodied educational design elements demonstrate themes used in developing educational innovation.

2.3 High-Level Conjecture

Identifying the high-level conjecture will shape other components in this educational innovation and require careful attention. This starts with looking at both the ESD studio's characteristics and the sustainable design approach that should be introduced. The previous chapter highlighted that developing a BD framework compatible with the ESD approach is the key strategy in bridging BD and ESD. Three challenges faced in developing a BD framework are identified thereafter and explored in detail in this section: (1) shifting the sustainability view to derive common categorisations for criteria, (2) a systematic method to bridge ESD and BD, and (3) integrating the BD framework into the design thinking process. Further, the support required to overcome these challenges in terms of learning theory and educational design elements are also outlined.

2.3.1 Shifting the Perception of Sustainability to Bridge Environmentally Sustainable Design and Biophilic Design

It is evident that an educational approach to facilitate BD requires developing a BD framework compatible with current ESD practice, however, the difference in the criteria used in BD and ESD frameworks contributes highly to their incompatibility. BD criteria focus on sensory place-making, while ESD criteria focus on building performance. These two categorisations of criteria for assessing designs make the integration of BD and ESD frameworks challenging.

Current green building rating tools (GBRTs), commonly employed as design frameworks in ESD, categorise criteria into the following groups: energy, water efficiency, resource use, site management and air quality (Building Research Establishment, 2013; U.S. Green Building Council, 2013). They also include aspects around the management of sites and construction, the engagement of professionals and innovation. These categories are focused on building performance. Each criterion is linked to concrete, quantifiable indicators that are used for awarding credits during certification. This provides transparency, and the design strategies can be easily replicated and adapted for other buildings.

In contrast, the available BD frameworks reference natural elements—such as the use of natural processes, nature in space, nature in place, direct experience of nature, the indirect experience of nature and evolved human–nature relationships (Browning et al., 2014; Kellert, 2008; Kellert & Calabrese, 2015)—to categorise criteria. These categories are focused on sensory place-making aspects and their criteria are highly qualitative and not easily measurable. Therefore, it is harder to provide firm evidence showing how well a particular criterion has been achieved. Further, BD is experienced as sensory stimuli, which, unlike ESD, is not always directly sensed or visible.

In short, sustainable design focuses on a building's technical characteristics, whereas BD focuses on sensory, spatial qualities. There is an epistemological gap between these two approaches: not only in their pragmatic application but also in the associated fundamental perception of sustainability. This gap is reflected in both education and practice. Creating a common categorisation for criteria that combines BD and ESD is a challenge. Adopting a new way of thinking about sustainability and the sustainable design can overcome this challenge.

A student's own perception of a sustainability is a critical factor for practising ESD. For example, Donovan (2018) emphasised the importance of students' critical reflections and active engagement for finding sustainable architecture theory relatable to their design practice. Further, Karol and Mackintosh (2011) stated that students' philosophical and personal positions on the principles and application of sustainability need to be developed if sustainable design is to become an integral part of their design practice. Luley (2020) noted that sustainability should begin from a philosophical, ethical and social perspective.

The perception of a sustainable built environment depends on how a person perceives the relationship between the built environment, nature and humans. Three orientations in a triangular relationship are identified by investigating how students develop their sustainability perception within the ESD studio: the built-centric view, the human-centric view and the nature-centric view. The built-centric view approaches sustainable design in terms of bringing benefits to building performance by merely mitigating environmental impacts. The human-centric approach focuses on achieving human comfort. The nature-centric view is premised on the built and the human being encompassed by nature and supports common criteria applicable to both BD and ESD. In promoting the adaption of BD within the current sustainable studio, a student's understanding of their orientation is a starting point for triggering their thought processes and developing their philosophy. This new way of thinking is further discussed in Chap. 3.

This type of learning wherein changes to students' attitudes are expected, falls into transformational learning (Munro & Grierson, 2018). Typical educational design elements that support transformational learning are the use of self-directed learning materials, lectures, participatory design and learning by doing. Research has revealed that hands-on experience, along with knowledge, can improve the transformation of thinking (Dabaieh et al., 2017). For recording a student's transformational learning process, critical reflections play a significant role (Berg et al., 2014).

2.3.2 Embracing a Systematic Technique to Generate Criteria for a Biophilic Design Framework Compatible with an Environmentally Sustainable Design Approach

To generate criteria that integrate BD and ESD and then use those criteria to develop a framework that guides student self-assessment is not so simple. In a situation where this integrated framework provides quality and standard for design, students should assess the BD framework's compatibility with the ESD approach and use it as a self-assessment guide. Nurturing this ability to judge their own work has been identified as 'evaluative judgement' in educational design (Goodyear & Markauskaite, 2019; Tai et al., 2018). Pedagogical design ideas that support evaluative judgement include self-assessment, the use of rubrics, peer assessment, feedback and the use of exemplars (Tai et al., 2018).

An exploration of the current literature reveals that the process for developing design frameworks has not been adequately discussed. This issue is not specific to BD—it applies to ESD as well. There is a lack of both theory and robust accounts of practice. One can only analyse current frameworks and speculate about the techniques that were applied during their development. For example, an analysis of literature regarding the 14 patterns of BD (Browning et al., 2014) showed that this BD framework was developed by drawing upon an extensive review of the literature about the benefits of BD and synthesising these into a few criteria. How these criteria were generated has not been described, but careful consideration reveals the inspiration from the previous framework by Kellert (2008).

The only available guidebook where the method for developing the BD framework is clearly outlined is recommended for use with the Living Building Challenge and is published by the International Living Future Institute (2018). It proposes an interdisciplinary ideation process, whereby different stakeholders come together to create a comprehensive BD framework.

In an education setting, interdisciplinary learning is frequently seen in ESD studios. This type of learning can assist the development of the framework but has its limitations in a design studio. For example, the key pedagogical design that supports interdisciplinary learning is role-playing. However, in a studio context, students may not have the adequate professional expertise to generate ideas by assuming another disciplinary or professional role.

In an educational setting, where a design framework is the critical design artefact that supports student learning, a more systematic and replicable technique is suggested. The design framework is also an assessment artefact and the systematic technique for framework development provides a foundation for transparent assessment of learning outcomes. This framework development activity involves students learning by way of constructing artefacts, through which students are also expected to develop a procedural knowledge of using a systematic technique.

Design studios predominantly nurture students' learning by having them construct design artefacts through their design projects. An embodied educational element that explains the step-by-step technique could support students in overcoming the challenge of developing procedural knowledge. For example, Dib and Adamo-Villani (2014) used serious computer games to support the development of students' skills in designing with a GBRT. They highlighted the importance of interactive learning materials that teach students procedural knowledge. The process-bridging technique (PBT) detailed in Chap. 4 is an embodied educational element developed to serve this purpose. The PBT supports students in generating criteria for their BD frameworks, and the guide in Chap. 4 provides further assistance in using these criteria, including instructions for synthesising them into a self-assessment tool. The theory around learning and educational design elements underpinning this approach is further discussed in Sect. 2.3.

2.3.3 Embedding Biophilic Design Frameworks in the Design Thinking Process

Designing in the studio encourages students to adopt a systematic design thinking process. According to Braha and Reich (2003), the design process is characterised by being a cyclic and exploratory endeavour and is generally depicted as a model. Although several design thinking models have been proposed, most of them share four broad phases: information collection, analysis, synthesis and evaluation (Lawson, 2005). The development of a design framework that supports sustainable design should be incorporated into these models for design thinking. The conventional design thinking models allow for information gathering and research, but they are more focused on studying similar buildings and finding inspiration. This typical design thinking may not consider supplying evidence for design decisions as a prominent need.

Consequently, there has been a growing awareness that, in the ESD context, design thinking approaches should suit the demands of ESD (Berg et al., 2014). For example, Karol and Mackintosh (2011) pointed out that, to grapple with the complexity of sustainable thinking, students need to be aware of their own learning and transformation. Further, this design thinking process should facilitate the rigour of the ESD process while also embracing BD's creative principles. It is also important to remember that the ESD approach requires showing evidence of sustainability achievement, which therefore demands an evidence-based design approach. Generally, in ESD studio projects, students are exposed to simulation software, which they use to model their design solutions and provide evidence supporting the design's sustainability. Therefore, these simulation software training programs are embodiments of educational design elements. Teaching students the required technical knowledge is crucial in the ESD approach and is integrated into design studios in certain ways (Altomonte et al., 2014) that are further explained in Sect. 2.3.3.

The typical design thinking process adapted by students may change with the addition of a design framework and other tasks related to ESD approach. The teaching within the studio should showcase students to understand the differences in design thinking process and model their own process rather than supply them with a new model. This demonstration will allow the students to individualise and develop their design thinking process, enabling them to use a similar process flexibly in their future design work. Further, students should be given opportunity to develop their own individualised design thinking that could nurture evaluative judgement. Arrangement of studio tasks in a certain way can promote a specific design process (Berg et al., 2014). This pedagogical idea is discussed in Chap. 7.

Finally, critical reflections are used to report on a student's design thinking process. Berg et al. (2014) reported on a study that attempted to map students' design thinking in a sustainable design project. In the study, the studio was structured around regular discussions aimed at supporting the design process. Students' critical reflections on the design process were a significant design artefact used in the study to model design thinking.

2.3.4 Mind-Mapping the High-Level Conjecture

While trying to understand the challenges faced in developing a BD framework compatible with the ESD approach, various pedagogical design ideas that could support overcoming these challenges were identified through an extensive literature review. A mind map was used to synthesise these ideas and derive a detailed high-level conjecture (Fig. 2.2).

As illustrated in Fig. 2.2, the pedagogical ideas include themes for both theoretical and design conjectures. The aim was to gather as many pedagogical ideas for deriving the high-level conjecture as possible. This made it possible to include a range of pedagogical ideas into the RACOM for BD frameworks, allowing it to be used in different situations.

Important theoretical ideas around the proposed strategy to overcome the challenges were highlighted in the above discussion. These included transformational learning, evaluative judgement, learning by constructing artefacts, developing procedural knowledge through practice, design thinking and reflective practice. How these ideas shape educational innovation is further discussed in the next section.

2.4 Theoretical and Design Conjectures

After identifying the challenges, theoretical assumptions were made regarding the type of learning required to support students and the educational design that may suit the desired learning. Before detailing the theoretical and design conjectures, an attempt was made to briefly connect the underpinning theories to the entire design process envisaged in this educational innovation.

Students learn develop BD frameworks and design sustainable buildings by constructing various artefacts. The term ‘artefacts’ or ‘design artefacts’ is used to refer to multiple objects that are created as part of the learning process, including a BD framework, building design and self-assessment report. Some of these artefacts are used to assess student learning outcomes. In such instances, they are referred to as ‘assessment artefacts’ (Markauskaite & Goodyear, 2017). Therefore, the key design conjecture is that a student’s learning process is mediated by constructing various design artefacts.

Identification of pedagogical ideas to support students’ construction of various artefacts influences all the educational design elements embodied in the educational innovation. Close investigation of the challenges in developing a BD framework revealed three distinct design artefacts students should construct: (1) an artefact that reflects the student’s sustainability perception, (2) an artefact that demonstrates the BD framework and (3) an artefact that illustrates the student’s use of the BD framework in their design thinking process. Each of these artefacts relates to different types of learning and embodied educational design elements.

The key theoretical assumption is that a student’s developed BD framework will guide them to assess their sustainable building design, thereby facilitating their evaluative judgement. Evaluative judgement refers to the capability to judge the quality of one’s own work and is particularly important in professional work and learning (Goodyear & Markauskaite, 2019; Sadler, 1989). It is expected that the construction of a BD framework and its use in the design thinking process, result in a sustainable and biophilic building design and students’ capacity to make sound decisions about BD in future. This is the key theoretical conjecture. Further exploring evaluative judgement as a learning outcome, Tai et al. (2018) proposed five educational design elements that support evaluative judgement: self-assessment, rubric, peer assessment, feedback and the use of exemplars. Thus, the evaluative judgement also influences the selection of educational design elements. Figure 2.3 shows how theoretical and design conjectures are associated with design artefacts and learning outcomes.

The central ideas embedded in Fig. 2.3 are *learning by constructing artefacts* and *evaluative judgement*; they guide the key theoretical and design conjectures. The developed BD framework needs to be integrated into the design thinking process for students to generate an ESD outcome that also embraces BD principles. This takes the discussion towards *design thinking* that, again, underpins both theoretical and design conjectures. The underlying theoretical assumption is that students require design thinking to integrate the BD framework into the design. Structure of the design studio tasks encourages students to follow a particular design thinking process, and this can be supported by appropriately arranging studio tasks.

There are numerous design thinking process models available, and reflective practice model (Schön, 1987) is widely used within architectural design studio pedagogies. Particularly in the ESD approach, a design outcome is a reflective response to a design framework. Reflective practice also makes thinking more visible; and students' critical reflections help teachers get insight into both change in students' perception and design thinking process. Therefore, design thinking, and reflective practice can be combined together into *reflective design practice* in the ESD studio.

Interdisciplinary learning, transformational learning and support for procedural knowledge also surfaced in the previous section. These are learning processes that are considered when deciding on educational design elements to support students in constructing design artefacts.

The key ideas that underpin theoretical and design conjectures—constructing design artefacts, evaluative judgement, design thinking and reflective practice—are briefly explained below.

2.4.1 Learning by Constructing Artefacts

Learning in the design studio is primarily focused on students constructing a design. Bertelsen (2000) stressed that a new epistemological understanding for design-led pragmatic learning is required. He further discussed how design is mediated by design artefacts, which he believes are crucial for understanding design-oriented epistemology.

With multiple design artefacts constructed within a design project, their different relationships with the design activity and the types of knowledge involved in their construction must be clarified. Bertelsen (2000) used an example from computer software development and defined three relationship between the design artefact and the design activity: construction, cooperation and conception. *Construction* is the productive relationship between the designing subject and the object of design that includes artefacts directly representing part of the final outcome. *Cooperation* is the representational relationship between subjects involved in the design. This includes artefacts made to communicate with team members of different disciplines cooperating with each other. *Conception* is the dialectical relationship between the designing subjects and the historically developing activity. This refers to artefacts developed based on a concept or model that is used in the design discipline. Bertelsen (2000) further stated that design artefacts, in most cases, mediate all three relationships.

In an ESD, a BD framework also mediates all three kinds of relationships. For example, a BD framework has a constructive relationship with the design because it represents an essential design artefact. The framework also has a cooperative relation because it represents different ESD aspects—such as energy, water and indoor air quality—that require varied disciplinary expertise and is, consequently, a design artefact that mediates cooperation among disciplinary and professional experts and stakeholders. Finally, the BD framework also has a conceptual relationship because it mediates the conceptualisation of different ESD approaches already in use and students' perception of BD: in a design studio, students working in a group bring their own personal ESD knowledge into the BD framework. Thus, the design framework is a design artefact that mediates all three relationships in the design project: construction, cooperation and conception. These multiple relationships position design frameworks as crucial learning and assessment artefacts.

Further exploring assessment artefacts, Markauskaite and Goodyear (2017) pointed out three types of assessment artefacts often used in professional learning: *cultural*, *conceptual* and *epistemic*. *Cultural* artefacts are generally developed and used for day-to-day professional practice, such as design proposals, drawings and documentation of concrete building designs in architecture. *Conceptual* artefacts are products of deliberative knowledge work aimed at constructing explicit articulated professional knowledge for professional judgements and practice. Some examples include developed design syntaxes and success matrixes used in the ESD approach. Such artefacts may contain knowledge to address specific problems in professional practice. However, these artefacts can usually be applied to varied situations to solve problems arising out of similar circumstances. Finally, *epistemic* artefacts link conceptual and cultural aspects of professional knowledge. They embody principled practical knowledge (Bereiter & Scardamalia, 2014) that enables practitioners to create customised context-specific solutions. Typical examples are design pattern books, design guidelines and other practical professional artefacts that enable practitioners to make design decisions while accounting for the unique challenges and multiple constraints that are encountered. Students' work in developing, adapting and applying BD frameworks for their own designs and then reflecting on their work involves an ensemble of conceptual, cultural and epistemic artefacts. Such complex artefacts facilitate students' development of professional knowledge that can be adapted to varied situations in their practice (Markauskaite & Goodyear, 2017; Markauskaite & Patton, 2019).

2.4.2 Evaluative Judgement

A student's BD framework is a crucial design and assessment artefact. As such, it can play a critical role in developing students' evaluative judgement, particularly their ability to judge the quality of their own work (Goodyear & Markauskaite, 2019; Sadler, 1989). Evaluative judgement is increasingly recognised as a learning outcome in higher education (Sadler, 1989; Tai et al., 2018) and crucial to preparing students for professional careers (Goodyear & Markauskaite, 2019). This ability also helps students become independent from their teachers (Tai et al., 2018) as it does not merely support the students to succeed in one particular course but also contributes to developing lifelong professional skills (Boud & Soler, 2016). Therefore, assessments that involve evaluative judgement, as Boud (2010) described, meet 'the needs of the present and prepare students to meet their own future learning needs' (p. 151).

Tai et al. (2018) suggest five types of pedagogical designs that support evaluative judgement: self-assessment, peer review, feedback, rubrics and exemplars. However, they note that evaluative judgement has not been extensively researched or theorised within higher education studies.

There have been, some studies in architectural design premised on nurturing a student's evaluative judgement, even though the researchers did not explicitly use the term evaluative judgement. For example, Hengrasmee and Chansomsak (2016) described a study that developed activities within the design studio to develop self-awareness, self-evaluation and self-criticism. They conducted a series of workshops wherein students could bring their ESD project, identify a problem and improve it through the workshop. Each workshop covered an aspect of ESD, such as energy efficiency or water management. The study suggested that one of the key assumptions of the educational design was that a student's ability to judge sustainability in their work was crucial for transforming their professional practices towards sustainability. Therefore, focusing on evaluative judgement is pertinent in ESD studios.

There are two integral components in developing evaluative judgement: understanding work quality and applying standards to one's own and others' work (Tai et al., 2016). In the case of the ESD studio, students' work in creating and using their design frameworks involves both components. A framework's development requires an understanding of various industry GBRTs, technical standards and benchmarks for sustainability criteria. Additionally, the use of the framework to develop design solutions inevitably involves applying standards for judging one's work quality.

Evaluative judgement is specific to a context and a domain (Tai et al., 2018). Therefore, to scaffold learning to nurture evaluative judgement, it is necessary to consider the interactive relations between students, tutors, educators and evolving industry standards while, at the same time, having students produce professional design work.

2.4.3 Design Thinking and Reflective Practice

Razzouk and Shute (2012) defined design thinking as 'an analytical and creative process that engages a person in opportunities to experiment, create and prototype models, gather feedback, and redesign' (p. 330). Design thinking is crucial in contexts with complex problems, such as the current environmental and sustainability challenges (Fry, 2009). The literature provides several models of the design thinking process, but there are concerns regarding their suitability for the level of complexity required by the ESD (Berg et al., 2014).

By closely investigating the design process in ESD, it is possible to notice similarities between the fundamental activities of the ESD and those typical in the conventional design: a creative and technological response to a certain problem—that is, reflection-in-action. Schön (1987) argued that reflection-in-action is the main way to develop the knowledge needed for professional practice. Studio teaching involves coaching students to reflect, in action, on complex design problems and learning-by-doing activities. Education within design studios has undergone various phases and the reflective practice model has emerged as dominant in conventional design studios. ESD studios share similar structural arrangements as conventional studios but also have two main distinguishing features.

First, the demands for technical knowledge tend to be much higher in ESD studios than in conventional studios. Therefore, teaching and learning activities ranges from lectures on sustainability principles to learning to use simulation software in computing labs. These teaching and learning activities can be structured and integrated with the studio activities in different ways. For example, Altomonte et al. (2014) identified five models for this integration: parallel, partially integrated, fully integrated, iterative and elective. In a parallel model, technical units are offered parallel to the studio, but these subjects are not connected to each other. In the partially integrated model, some of the technical knowledge is integrated into the studio and others run parallel. In the fully integrated model, all technical knowledge is embedded into the studio. In the iterative model, technical knowledge is provided when needed, depending on the briefs. Finally, in the elective model, technical units are offered as optional electives that students may choose according to their preferences or requirements.

Second, design frameworks play a distinct role in reflection. Schön (1983) described the studio as a practicum that can be:

> reflective in two senses: it is intended to help students become proficient in a kind of reflection-in-action, and when it works well, it involves a dialogue of coach and student that takes the form of reciprocal reflection-in-action. (p. xii)

In ESD studios, the design framework sets the parameters for a sustainable response and inevitably shapes the reflection-in-action. In some ways, the framework plays the role of the 'coach', particularly when industry frameworks are used or when frameworks provide guidelines and strategies for achieving the desired outcome.

2.5 The Proposed Educational Design: Learning Outcomes, Mediating Processes and Embodiments

The educational innovation project proposed in this book aims at empowering students to autonomously develop a BD framework integrated within the more traditional ESD approach. It opted for a fully integrated model, where technical knowledge is embedded within the studio, and structured to focus on a success matrix that provides an artefact for both the tutor and the student to relate to and guide the self-assessment.

Identifying the learning outcomes, mediating processes and embodied educational design elements was an iterative process that required moving back and forth. The three artefacts that later mediate biophilic and sustainable building design are also

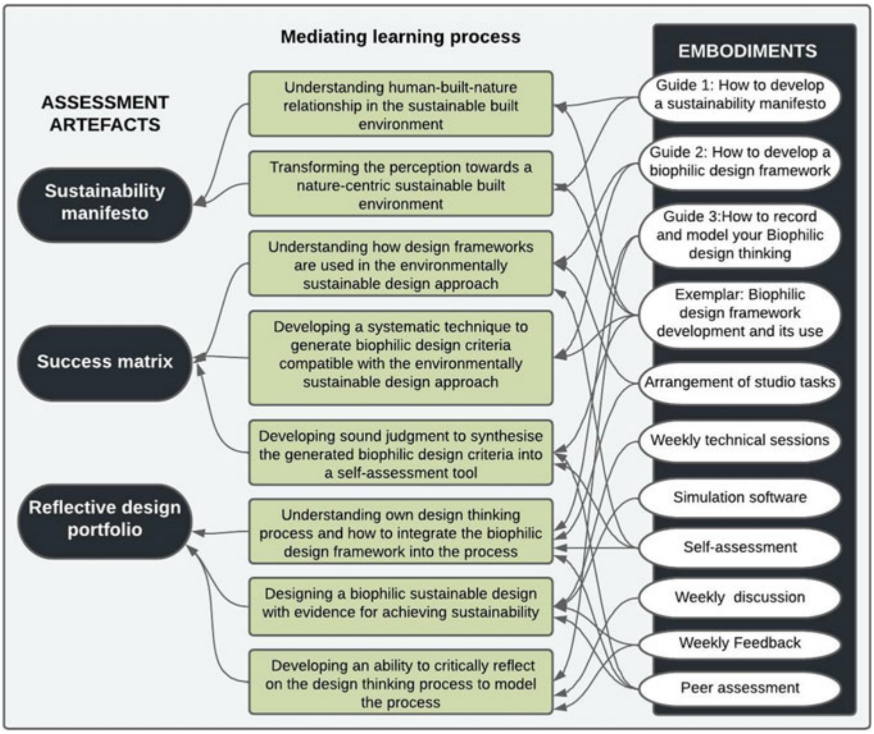

Fig. 2.4 Assessment artefacts and their associations with mediating processes and embodiments

used as assessment artefacts. Figure 2.4 shows the assessment artefacts and their relationships to mediating processes and embodiments.

As illustrated in Fig. 2.4, few mediating processes are reflected in the three assessment artefacts (sustainability manifesto, success matrix and reflective design portfolio).

Embodiments include following materials as guides: (i) guidelines and references to elaborate a sustainability manifesto, (ii) a systematic technique to develop a BD framework as a self-assessment tool, (iii) guidelines for the application of a sustainable and biophilic design thinking model and (iv) an exemplar showing the step-by-step process. Each guide supports students in transiting through the mediating processes and achieving learning outcomes by constructing an artefact. The guides are written as ready-to-use tools for students. The underlying idea is that educators can embed the BD teaching approach described in this book within their teaching practice by scaffolding student progression using the guides in the studio.

The three guides to the assessment artefacts are outlined in the remainder of this chapter; Chaps. 3–5 present the guides themselves. Chapter 6 presents the exemplar. Other embodiments are discussed as practical implications in Chap. 7.

Within the following subsections, specific conjecture maps for each of the three assessment artefacts are given, and a discussion is provided as to how embodied educational design elements support students in constructing assessment artefacts. Learning outcomes, and theoretical and design conjectures, are also included in these detailed conjecture maps of each assessment artefact.

2.5.1 Development of a Sustainability Manifesto

As outlined in Sect. 2.3.1, shifting the perception of sustainability is a challenge within ESD studios when BD approaches are integrated. A task that asks students to develop a sustainability manifesto responds to this challenge.

A sustainability manifesto helps students reflect on their perception of a sustainable built environment by rethinking the relationships between the *human*, the *bui*lt and *nature*. Producing this artefact also mediates the development of the BD framework. Figure 2.5 shows the association between theoretical and design conjectures of the assessment artefact with the learning outcomes and embodiments.

As illustrated in Fig. 2.5, two mediating learning processes are required to complete this assessment artefact. First, the students need to understand the relationship among—*human*, *built* and *nature* and how those interrelations assign different interpretations to the sustainable built environment. Second, students should shift their perception towards a nature-centric sustainable built environment. The assumption is that students with a nature-centric perception could produce sustainable designs with higher biophilic quality. The evaluation of the sustainability manifesto should demonstrate the achievement of two learning outcomes: (1) a perception of sustainability that encompasses BD within ESD, and (2) the ability to generate BD criteria compatible with the ESD approach. A practical guidance for students is given in Guide 1 (Chap. 3) and illustrated in the Exemplar (Chap. 6).

2.5.2 Development of a Biophilic Design Framework Within the Success Matrix

The term ‘success matrix’ is here used to identify the design framework that guides students’ sustainable designs, traditionally employed in ESD studios. Students should be given the flexibility to develop their own success matrix, including design criteria, performance and evaluation rules, with the intent to give them an occasion and a tool to reflect upon their achievement of sustainability in the final design. Three mediating learning processes are required to successfully develop this artefact. Figure 2.6 illustrates how embodiments and learning outcomes are related to the design and theoretical conjectures.

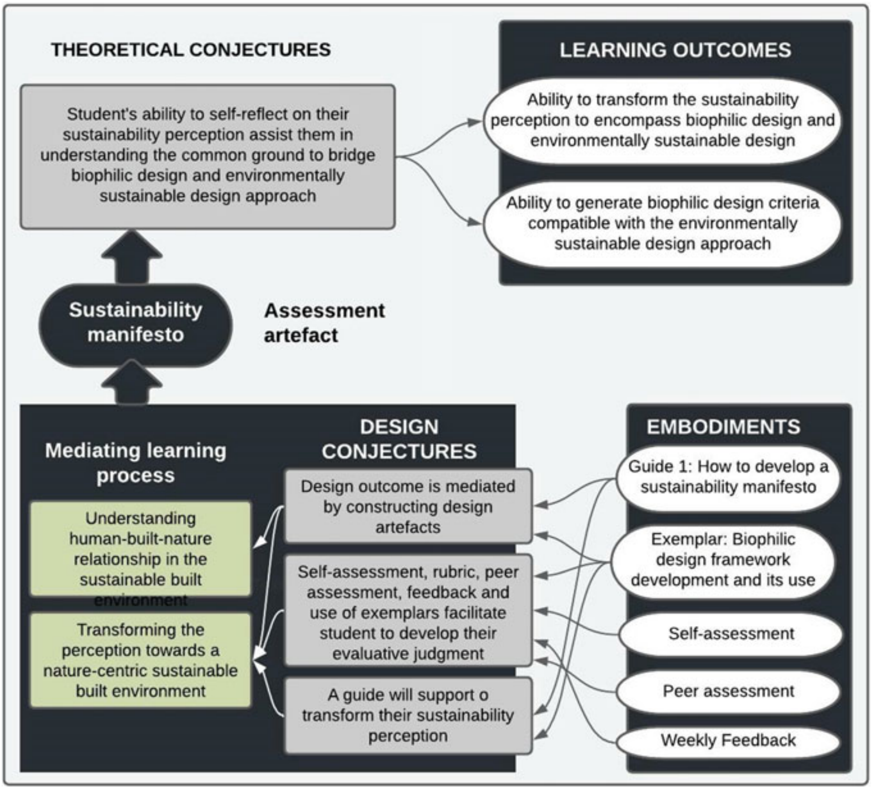

Fig. 2.5 Conjecture map for sustainability manifesto

There are three mediating learning processes necessary to construct this artefact. First, students need understand how design frameworks are used in ESD. A brief analysis of the current industry GBRTs and BD frameworks is included in Guide 2 (Chap. 4) that could be used to support this learning process.

Second, students are expected to learn a systematic technique to generate BD criteria compatible with the ESD approach. Guide 2 provides specific instructions on bridging the two approaches and generating compatible criteria. Peer assessment is an embodiment that can support students in this task through critical evaluation and discussion.

Third, students can use the generated BD criteria as:

- Integrated part of the success matrix, included as a separate category,
- Integrated into the success matrix where BD criteria are scattered across categories,
- BD framework is taken as the success matrix and further developed as a self-assessment tool to evaluate the biophilic response.

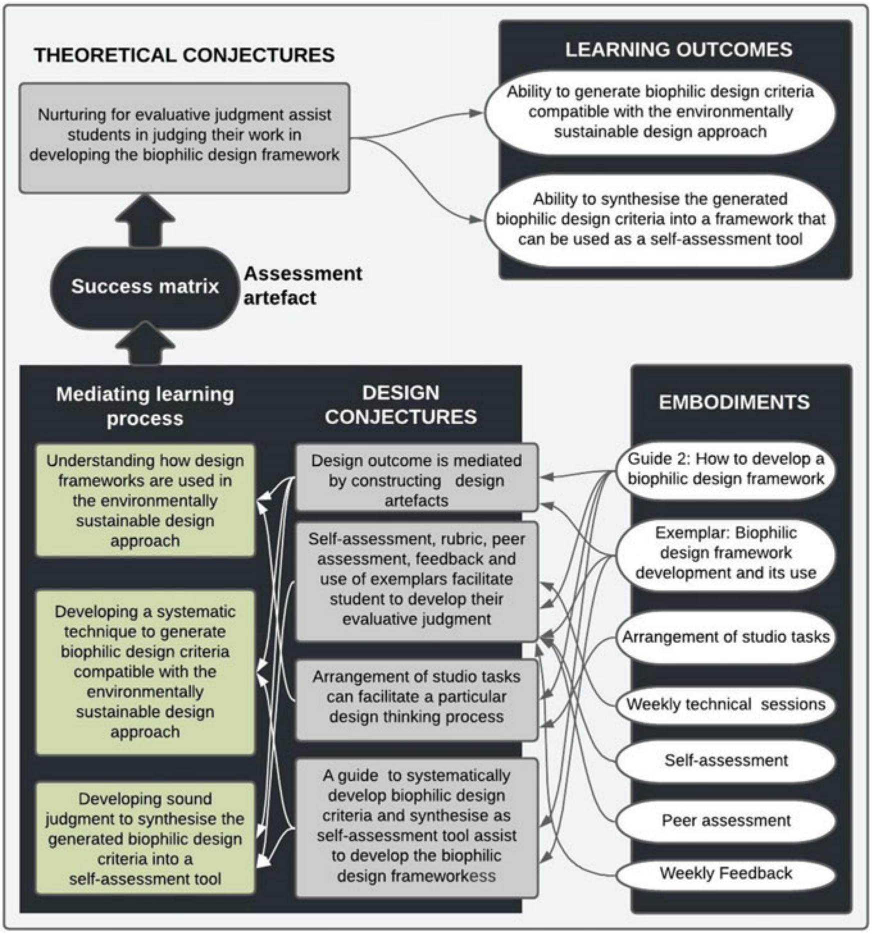

Fig. 2.6 Conjecture map for the success matrix

Guide 2 has instructions for the three approaches. It is suggested that the criteria are used as a self-assessment tool so that it will support nurturing evaluative judgement. By going through the exemplar provided in Chap. 6, students will learn the application of all three mediating learning processes.

Two learning outcomes are demonstrated by this assessment artefact: (1) the ability to generate BD criteria compatible with the ESD approach and (2) the ability to synthesise the generated BD criteria into a framework that can be used as a self-assessment tool.

2.5.3 *Use of the Biophilic Design Framework in the Design Thinking Process and Reflecting*

Once a BD framework is constructed, students use this framework in the design thinking process. A reflective design portfolio can be used as the key assessment artefact to demonstrate their design thinking process. In addition to be developed as a design portfolio it should include reflections on their design journey through the project. Four mediating learning processes are involved in the construction this artefact (Fig. 2.7).

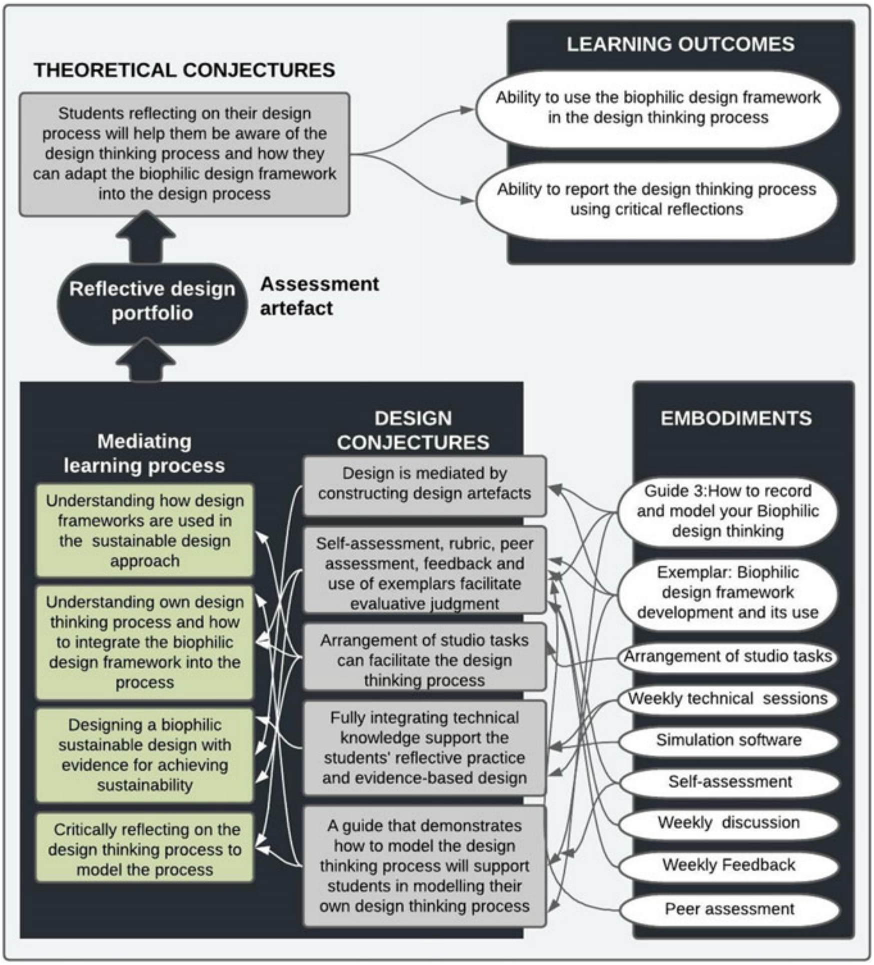

Fig. 2.7 Conjecture map for the reflective design portfolio

The first mediating learning process is understanding how design frameworks are used in the ESD approach. The second one requires students to understand their design thinking process and how to integrate the BD framework into that process. It introduces five design thinking models that students can use to explore and identify their own design process. The arrangements of studio tasks and peer assessments are also included as embodiments to support this mediating learning process.

The third mediating process engages students in the design of a biophilic and sustainable building, and provision of evidence of the achievement of sustainability. Within an ESD students are required to support their claim on sustainability with evidence-based design practice. Weekly technical knowledge teaching embedded in the studio will prepare the students for this.

The fourth mediating learning process is students' critical reflection on the design thinking process. Peer assessment—whereby students can critically look at how others are modelling their process—is also crucial for this mediating learning process. The purpose of Guide 3 (Chap. 5) is to support the students with above tasks.

The exemplar given in Chap. 6 shows a specific design thinking process that resulted in a sustainable design with high biophilic quality and also shows how to work through all the mediating learning processes discussed above.

By constructing this artefact, students can achieve two learning outcomes: (1) the ability to use the BD framework in the design thinking process and (2) the ability to articulate the design thinking process through critical reflection.

2.6 Reflective Action Conjecture Map Development Process

Figure 2.8 provides an outline of how the RACOM for BD frameworks was developed in this proposed educational innovation.

Step 1: The process started with deriving the high-level conjecture and identified key challenges in developing a BD framework, as well as the pedagogical ideas that can support overcoming these challenges. A mind map was created to derive the high-level conjecture with the supporting pedagogical ideas (Fig. 2.2).

Step 2: Then, pedagogical ideas were investigated in relation to the design artefacts that mediate the development of a BD framework. By doing this, the theoretical and design conjectures for educational innovation were identified (Fig. 2.3).

Step 3: Consequently, the assessment artefacts and mediating learning processes for each of those artefacts and the embodiments that could support the students in the learning processes were identified (Fig. 2.4). This step was an iterative process, comprising four sub-steps aimed at assisting in the generation of the themes of a RACOM for BD frameworks.

Clearly, mediating learning processes are agile. They depend on the design brief of the project and the context. Identifying the mediating learning processes assist in linking between the learning outcomes and embodiments through theoretical and design conjectures. The alignment of the learning outcomes, assessment artefacts,

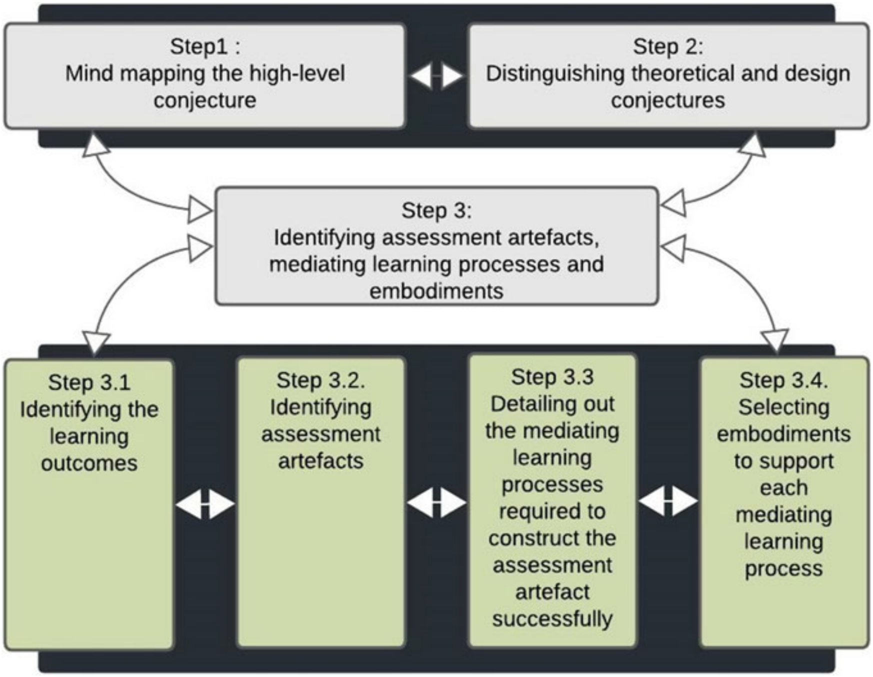

Fig. 2.8 Development of a reflective action conjecture map for biophilic design frameworks

mediating processes and embodiments is an iterative process that requires moving back and forth between these components.

2.7 Concluding Remarks

This chapter outlined the development of the educational design innovation for BD frameworks based upon RACOM, a systematic approach to develop educational innovations for sustainable design studios. Authors have implemented a similar RACOM for BD where the insights from it's evaluation and the reflections were taken into consideration whilst developing this version.

The RACOM developed for BD included three design artefacts that are also assessment artefacts, providing materials to support students in successfully transitioning and achieving learning outcomes. Each design artefact corresponds to mediating learning processes linking learning outcomes with necessary embodiments. These mediating learning processes were expanded connecting the theoretical and design conjectures providing educators with an ability to adapt them in similar situations. How these assessment artefacts could be evaluated is discussed in Chap. 7.

This guidebook includes three guides and the exemplar as the materials within the embodiments detailed out in following chapters. Each Student Guide was developed to support an identified challenge where the exemplar demonstrated the use of the introduced design approach. They are presented in a way that can be directed used in the studio to suit the learning outcomes used in the proposed educational innovation. Educators will need to adapt the given learning outcomes to their contexts, along with potential assessment artefacts and other components. The implications educators may face in implementation and embodiments other than materials are given in Chap. 7.

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