Reflecting on sustainability: coproducing a critical framework for sustainable design in the architectural studio

Robert Grover, Stephen Emmitt and Alex Copping

Architecture and Civil Engineering, University of Bath, Bath, UK

ABSTRACT
Due to the holistic and often contradictory nature of sustainable design, learning for sustainability in the architectural design studio requires students to adopt critical and reflective practices. This research developed a reflective mapping framework to enable deep learning. It was created through a participatory action research methodology within a learning environment parallel to the design studio. The framework was used to inform approaches to sustainability at conceptual design stage. It encouraged participant engagement, understanding and reflection. This form of structured group learning is a possible alternative to the one-to-one tutorial for enabling deep learning in the design studio. The research highlights the importance of alternative learning environments to the design studio that can encourage critical reflection. This research contributes to design pedagogy by describing a methodology for enhancing deep learning for sustainability through participatory action.

ARTICLE HISTORY
Received 4 June 2018
Revised 2 May 2019
Accepted 20 May 2019

KEYWORDS
Design studio; sustainable design; architectural education; participatory action research

Introduction

Schools of architecture are typically centred around the design studio, a term used to describe a physical environment, a teaching event and a pedagogy (McClean, 2009). The studio-based teaching model emerged as an extension of the workplace, however, operates in a structured academic setting drawing from an apprenticeship model of education (McClean, 2009). This research aims to enhance learning for sustainability in a postgraduate architectural design studio in the UK. This paper describes the creation of a ‘reflective framework’ which enabled students to critically reflect on their own sustainable design practice. This reflective framework is a structured learning tool; a method for categorising and interpreting design solutions to enable critical analysis. Adopting a participatory action research method, a group of volunteer students, led by the researcher, reflected on the nature of sustainability in the design studio. A series of workshops provided space for developing a shared critical understanding of sustainable design beyond the limitations of course requirements.

In the context of this research, sustainability is considered a pluralist concept which captures a range of environmental, social and economic discourses (Hajer & Versteeg, 2005). Sustainability and sustainable design, therefore, are contestable fields which are
subject to change (Cook & Golton, 1994). In architectural design, this manifests itself as a series of competing ‘logics’ which offer different interpretations of sustainable concepts, as well as alternative built responses (Guy & Farmer, 2001). This research seeks to raise a critical awareness of the issues that may be considered (Cook & Golton, 1994) to form contextual and individual meanings of sustainability.

**Architectural education and sustainability**

A wide-ranging study of international architecture schools was conducted by the Environmental Design in University Curricula and Architectural Training in Europe (EDUCATE) project (Altomonte, Attia, Herde, & Dartevelle, 2010). Of the 62 international institutions considered, the design studio was the dominant mode of education. Delivery of sustainable design content, however, typically occurred in satellite modules. In the seven schools of architecture in the UK considered by the EDUCATE project, all adopted this approach, focussing on the application of principles delivered in lectures to design projects. This has been advocated in engineering education as it provides students with the skills to deal with both hard and soft problems (Fenner, Ainger, Cruickshank, & Guthrie, 2005). Satellite and elective modules can provide valuable support specific to the core learning environment of the studio (Hassanpour, Alpar Atun, & Ghaderi, 2017). However, dividing the curriculum in this manner relies on the assumption that knowledge can be acquired then applied (Gelernter, 1988). This pedagogic dichotomy in which knowledge is ‘front loaded’ has been criticised for being ineffective due to the non-sequential nature of learning (Gelernter, 1988). Drawing from the cognitive theory of Piaget (1971), Gelernter suggests that practice and acquisition operate in a recurring cyclical relationship. An overreliance on didactic pedagogies undermines constructivist epistemologies and reduces knowledge to ‘information and skills’ which embed assumptions and beliefs (Crysler, 1995). This has led to project-based approaches in which students assemble a portfolio of data which is then questioned by educators (Douvlou, 2006) often based on the tutor’s own intuition (Webster, 2004).

Sustainability poses a unique challenge to architectural education. It is holistic in nature, operates at multiple scales and over different time periods. Moreover, the range of discourses the term encompasses (Hajer & Versteeg, 2005) necessitates a critical approach, to analyse and appraise competing interpretations (Gürel, 2010; Guy & Moore, 2007). Hemsath (2017) suggests traditional architectural pedagogy may not adequately prepare future architects for the challenges of future sustainable design. Indeed, entrenched approaches to architectural education can hinder transformational changes required to integrate sustainability (Olweny, 2018).

**Sustainability and deep learning**

Dealing with the challenge of sustainability requires an integrated approach that goes beyond the addition of content (Warburton, 2003). Not only must it be embraced in syllabi but students must be exposed to diverse perspectives, apply ideas in context and engage in emancipatory processes. A constructivist approach to education and sustainability can lead to changes in students thinking processes rather than merely the application of knowledge (Howlett, Ferreira, & Blomfield, 2016).
Deep learning describes a level of information processing which focusses on underlying meaning (Marton & Säljö, 1976). Implying a critical approach to understanding in which assumptions are challenged through reflection. Deep learning is particularly relevant to educating for sustainability due to its holistic nature (Buckingham-Hatfield & Evans, 1996). Above all, it requires internal motivation; the learner must have a desire to understand (Warburton, 2003) in which student-centred pedagogies to take prominence and reflective educators to enable this (Clune, 2014). Beattie, IV, Collins, and McInnes (1997) describe three primary characteristics of deep learning.

(1) “Seek to understand the issues and interact critically with the contents of particular teaching materials;
(2) relate ideas to previous knowledge and experience and;
(3) examine the logic of the arguments and relate the evidence presented to the conclusions.” (p.3)

As the primary means of educating architects, integrating deep learning for sustainability into the design studio is a key concern (EDUCATE, 2012). The design studio appears an ideal site for deep learning as it encourages both independent and problem-based learning, however sustainable design is often side-lined or ignored (Clune, 2014). The learning processes in the design studio, described by Schön (1984, 1985), focuses on the development of tacit knowledge through iterative processes, rather than broader reflective practices. Reflection-in-action describes the process of design through a constant reflective dialogue during the act of creation and is considered important for developing professional expertise (Schön, 1985). However, the pursuit of professionalism through the design studio may serve to promote a ‘hidden agenda’ embedded within the industry (Dutton, 1991) supported by hierarchical teaching structures and self-referential values (Till, 2003). As Hemsath (2017) suggests, architecture courses must provide varied educational experiences that celebrate the pluralism of sustainable design.

While the traditional architectural design studio offers a variety of spaces for both reflection-in-action (through the design process) and more deliberate evaluative processes (such as the one-to-one desktop tutorial or formal design reviews by a panel of teaching staff), there is seldom space to critique its own internalised practices and embrace ideas beyond accepted conventions (Banham, 1991; Till, 2003). The medium of the design project and the focus on production often distract from examining underlying values (Bashier, 2014; McAllister, 2010; Till, 2003). The teaching of sustainable design principles (such as strategies for low energy design or the use of natural building materials) through taught modules may enhance product in the design studio; however, the capacity for critical analysis is compromised.

To enable deep learning for sustainability, students must be encouraged to ‘identify assumptions, research them, and generate multiple perspectives’ (Brookfield, 1997) (p., p. 25) as well as to engage emotionally and analyse their own responses (Rogers, 2001). This research sought to create a space beyond the design studio to enable these critically reflective practices. Adopting a constructivist epistemology, knowledge was co-produced by participants (Gibbons et al., 1994) who became both the subjects and generators of the research. Students formed an independent learning group which was used to implement change through an emancipatory paradigm (Zuber-Skerritt, 1996).
Developing a framework

The complexity of sustainability as well as its contestable nature have led to a number of attempts to provide overarching conceptual maps, often shaped by two competing world views. These have been described variously as: the technophilic and the technophobic (Brand & Fischer, 2013); the expansionist and the ecological (Jepson, 2004); technology development and deep ecology (Jackson & Ravetz, 2000); and innovation and restraint (Symons & Karlsson, 2015). They represent two distinct epistemological paradigms: a positivist view grounded in objective reality that the environment can be managed by innovation; and a social constructivist view that environmental issues can be addressed through altering ethical frameworks.

Hopwood, Mellor, and O’Brien (2005) provide a model of sustainable development which contrasts environmental concerns against social ones to map various sustainability paradigms building on the work of O’Riordan (1989) and (Pearce, 1993). Dusch, Crilly, and Moultrie (2010) then apply these principles to a model of sustainable innovation which allows categorisation of types of sustainable design activities (Figure 1).

Dusch’s framework positions eco-centrism and techno-centrism as perpendicular domains through which sustainable activity can be categorised. For the authors, optimal sustainable action combines technical innovation with changes in consumption behaviour.

![Figure 1. A framework for mapping sustainable design activities redrafted from Dusch et al. (2010).](image-url)
to generate new scenarios, advocating a hierarchy consistent with similar frameworks by Vezzoli and Manzini (2008), Ceschin and Gaziulusoy (2016) and Tischner and Verkuijl (2006).

Guy and Farmer (2001) present a typology of sustainable paradigms specific to architecture which challenge the assumption of optimal design solutions. Through analysis of the literature they define seven eco-logics which each describe paradigmatic approaches to the problem of sustainable design. Rather than reaching a consensus, multiple realities offer competing interpretations of the sustainable agenda. Celebrating this pluralism, they suggest that through a critical approach, different logics may work together to reach limited goals and challenge the primacy of technical solutions. This search for consensus is, however, undermined by the social-constructivist nature of environmental problems in which concepts such as ‘nature’, ‘the environment’ and ‘ecology’ are contextually bound (Hannigan, 2014) and linked to wider social values (Jamison, 2001).

**Research aim**

The research aims to develop a reflective mapping framework for enhancing deep learning for sustainability in the studio. Using a participatory action research approach, it seeks to provide a space for structured reflection-on-action and examine the capacity for a parallel learning environment to the design studio to enhance practice. It uses the framework presented by Dusch et al. (2010) as a point of departure for a reflective tool in the design studio. Drawing from the work of O’Riordan (1989) and Hopwood et al. (2005) the research uses the contrasting domains of eco-centrism and techno-centrism to frame competing approaches.

**Context of the research**

The research was conducted in the first six-month period of a Royal Institute of British Architects (RIBA) Part 2 MArch course at a leading UK institution. The course was 18 months, full time and had 43 enrolled students, all of whom had undertaken RIBA part 1 validated courses in the UK as well as spending at least one year in practice. The design studio was structured around an individual project in which students were given a site however had considerable freedom to develop their own briefs. Design studio tutoring and frequent ‘crits’ (formal design reviews in front of a panel of tutors) were supplemented by presentations and a stand-alone lecture course in sustainable design. The project took place over a 15-week semester.

**Method**

The research utilised a participatory action research (PAR) framework. The participatory and social nature of PAR make it highly applicable to an educational context, especially the design studio. PAR offers a means for effecting change at a local level (Cohen, Manion, & Morrison, 2000) incorporating institutional and individual transformations (Brydon-Miller, Greenwood, & Maguire, 2003). In this sense, it differs from more traditional research in the social sciences which often focuses on representation rather than action (Reason & Bradbury, 2008). In alternative methodologies, both quantitative and qualitative,
participants are often considered passive subjects; however, in PAR, they are active engagers in the research process (Whyte, 1991, p. 20). This direct engagement was important to empower participants to create their own practical knowledge for application in the design studio. Moreover, placing learners at the centre of the environment is essential for experiential learning (Kolb & Kolb, 2005) and provides opportunities for change from a bottom-up, learner perspective. The method draws from theories of knowledge co-production (Gibbons et al., 1994) to develop social and collaborative change.

**Planning the environmental sustainable design action group**

An environmental sustainable design action group (ESDAG) was created and aimed to meet on a bi-weekly basis, for one hour in an informal workshop. The workshops were the primary means of formal interaction of members however it was anticipated informal interactions would take place within the design studio.

Members of the ESDAG were drawn from the MArch cohort on a voluntary basis with a flexible membership, whereby no-one was excluded and were free to join at any point in its existence. Students were made aware of the action group at their initial design studio meeting (week 1) and asked to volunteer. This voluntary sample is consistent with the development of similar learning communities (Wenger, 2000) and its actions were defined by what the members considered important. Its scope extended beyond benefits for its members and the rest of the design studio was considered its audience.

The ESDAG was introduced to students in the first month of their course (week 1) and had its first meeting the following week (week 2). The group had four workshops in total, each lasting for an hour. The workshops were delivered across a single semester and were timed to avoid coinciding with course deadlines. The group aimed to meet every second week to give participants a chance to reflect on the workshops and examine the real application of the workshops in the design studio. It also limited participant time commitments to the group. The workshops were sequential with the findings of the previous workshop informing each subsequent workshop. The nature of the meetings was defined by the researcher; however, content was primarily student led. Collaborative and independent learning was supported by the open nature of the workshops and the student led focus of the workshops.

In participatory action research, researchers and participants are jointly responsible for the creation of knowledge (McIntyre, Chatzopoulos, Politi, & Roz, 2007). In this study, the researcher was an ‘observer-as-participant’ (Cohen et al., 2000) responsible for guiding each workshop and facilitated any actions taken. The participants defined the initial content, developed this content and critically evaluated previous sessions. The agency of the researcher was necessary to avoid ethical considerations of overburdening the participant who were already under considerable stress from compulsory studies.

**Structure of the workshops**

**Workshop 1**

The first workshop was an introductory session to introduce the group to each other, to determine specialist skills and knowledge and to propose possible ideas for action. The researcher outlined research and its motivation. The group’s objectives and aims were
also presented and discussed. The first workshop was attended by 12 volunteers and the researcher. It involved active engagement from participants who all engaged in discursive activities facilitated by the researcher. The structure of the first workshop is outlined in Table 1.

### Workshop 2

The intended outcomes of the second workshop were to validate the findings of the first workshop, develop a means of critically assessing approaches to sustainable design and introduce the group to different sustainable design paradigms identified in the literature. A framework for sustainable design (Figure 2) was presented, based on the axes defined by Dusch et al. (2010) with the typologies of sustainable design and their characteristics drawn from Guy and Farmer (2001) mapped to it. The researcher plotted these paradigms and presented them as to stimulate discussion surrounding each type. A number of ‘typical’ projects that characterise each paradigm were presented, drawn from the exemplars provided by Guy and Farmer (2001). The intention was to allow any architectural example to be considered for its sustainable credentials.

The second workshop was attended by 14 participants (12 of whom attended the first workshop) and the researcher. It involved active engagement by participants but operated as a reflective focus group whereby students critically assessed sustainable paradigms in the literature. The second workshop took the format outlined in Table 2.

### Workshop 3

In the third workshop, responding to the outcomes and reflections of the second workshop, a mapping tool (developed from workshop 2) was populated with predefined precedents which represented contestable sustainable concepts (Figure 3). It utilised a non-hierarchical axis presenting conflicting views of sustainability. Each example represented an idealised archetype. The framework provided a conceptual synthesis between the unstructured typological approach of Guy and Farmer (2001) and the continuum of Hopwood et al. (2005). Categories derived from the eco-logics of Guy and Farmer (2001) and were adapted and plotted to represent ideal paradigms. The intended outcomes of the third workshop

---

**Table 1. Structure of workshop 1.**

| Topic                                               | Time | Notes                                                                                                                                 |
|-----------------------------------------------------|------|---------------------------------------------------------------------------------------------------------------------------------------|
| 1. Introduction to the research                    | 10 min | The background to the project was presented by the researcher and the motivation for conducting the research was explained.          |
| 2. Introduction and experiences of members          | 15 min | Members introduced themselves and discussed their experiences, interest in sustainability and particular expertise.                   |
| 3. Introduction to the sustainable mapping frameworks| 10 min | The researcher introduced the participants to the literature surrounding sustainable frameworks.                                      |
| 4. Brainstorming possible issues and initial ideas for action | 10 min | A post-it note exercise in groups of four was undertaken and participants generated possible ideas for action and change to improve sustainable teaching in the design studio. |
| 5. Mapping and discussion of possible actions       | 10 min | The group discussed the possible actions generated in terms of what aspect of the experiential learning cycle they would enable, their likely impact and practical consequences. |
were to refine the sustainable design framework by identifying strengths, weaknesses and opportunities for its use as a critical thinking tool in the design studio.

The third workshop was attended by 12 participants, all of whom had attended the second workshop. It began by validating the previous workshop’s findings and confirming them with the group. The typological model was presented with exemplar projects used to support the typologies. A semi-structured group discussion then followed, facilitated by the researcher, offering feedback on the model. The group was first asked if they could identify the assumptions embedded in each particular paradigm. Secondly, the structure of the framework and possible means of implementation in the design studio were discussed. Finally, possible actions and next steps were considered. Table 3 describes the structure of the workshop.

**Workshop 4**
The intended outcomes of workshop 4 were to test the framework and to examine possible critically reflective techniques for its application in the design studio. It drew from methods for encouraging critical reflection including concept mapping (Novak &
Table 2. Structure of workshop 2.

| Topic                                      | Time | Notes                                                                 |
|--------------------------------------------|------|----------------------------------------------------------------------|
| 1. Reflections from previous workshop     | 10 min| Reflections and conclusions from the previous week were validated by the group. |
| 2. Introduction to mapping sustainable paradigms | 15 min| The researcher introduced a critical framework to map sustainable paradigms derived from the literature. This was based on the need for meta-analysis which emerged from the first workshop. |
| 3. Examples of sustainable paradigms presented | 10 min| The researcher presented concrete examples of sustainable paradigms through case studies identified in the literature. |
| 4. Discussion based on incorporation of ideas into the studio | 10 min| The researcher facilitated an open discussion based on the critical framework and examples presented. |
| 5. Possible actions and next steps         | 10 min| Based on discussion                                                   |

Figure 3. Sustainable typological framework with exemplar typologies modified from Guy and Farmer (2001).
Cañas, 2006), mind mapping (Biktimirov & Nilson, 2006) and argument mapping (Twardy, 2004) which utilise a graphical form to organise information, reveal relationship and encourage understanding, in turn, promoting deep learning (Davies, 2011; Entwistle, 2013). Maps can contain large quantities of information expressed in the physical relation of ideas (Winn, 1991) and have been shown to improve critical thinking, enhance engagement in learners and deepen understanding (Twardy, 2004).

An adapted version of concept mapping was used (Davies, 2011). The advantage of this method over other critical reflective techniques was that it allowed the generation of a wide variety of possible concepts which could then be plotted to the critical framework and clustered as well as offering a structured approach. The technique also allowed dynamic restructuring of information, appropriate for mapping concepts to the grid. Davies (2011) and Trochim (1989) provide a stage based processes of concept mapping. Drawing from this literature, the workshop was structured around this process (Table 4). Workshop 4 was attended by four participants, who had attended all previous workshops.

**Validation interviews**

Feedback was gathered through individual and group interviews with the four members of the group that had completed all the workshops. Standardised, open-ended interviews

---

**Table 3. Structure of workshop 3.**

| Topic | Time | Notes |
|-------|------|-------|
| 1. Reflections from previous workshop and on framework implementation | 10 min | Reflections and conclusions from the previous week were validated by the group. The testing of the initial framework was discussed. |
| 2. Further development of framework | 15 min | The facilitator introduced a developed framework and provided further examples to support the identified typologies. |
| 3. Identifying assumptions of framework | 10 min | The group were asked to identify assumptions associated with each typology in an open framework. |
| 4. Application of precedents to framework | 10 min | The researcher facilitated an open discussion based on the presentation and means to incorporate it into the design studio. |
| 5. Possible actions and next steps | 10 min | Possible actions were discussed based on the outcomes of the workshop. |

---

**Table 4. Structure of workshop 4.**

| Topic | Time | Notes |
|-------|------|-------|
| 1. Reflections from previous workshops and the teaching in sustainability to date. | 15 min | The group reflected on their current teaching of sustainability over the previous three months and provided insight into how they were utilising the content of the workshops in the design studio. |
| 2. Brainstorming exercise | 10 min | The question of how can architecture be sustainable was posed and a post it-note brainstorming exercise of statements was undertaken. |
| 3. Idea mapping | 20 min | Each statement was mapped to the framework depending on how ‘high-tech’ it was or how ‘social’ it was. This was facilitated by the instructor. Miscellaneous statements were pooled to one side. |
| 4. Reflections from the exercise | 10 min | The group reflected on the workshop and were asked whether this approach could be applied to projects, how useful the approach was and how it may be made more valuable. |
(Patton, 1980) were conducted 4 months after the end of the workshops to understand how the students might apply the framework in their design work. They were structured around five subheadings: reflections on the content workshops; reflections on the pedagogy workshops; changes in personal motivation; learning and relevance of the workshops; and possible modifications for the future.

**Data collection**

Each workshop was audio recorded and transcribed and photographic evidence of key outcomes was taken. Ongoing field notes were also made and categorised *in-situ* (Lincoln & Guba, 1985). These were supplemented by reflective notes which allowed continuous post-analysis of observations. All interviews were also audio recorded and transcribed.

**Data analysis**

Data were analysed based on the framework outlined by Glaser and Strauss (2009), modifying the process of data analysis for action research provided by Hinchey (2008). Data were initially coded (unitised) and then categorised derived through clustering associated codes. These categories then formed larger domains for analysis. Relationships and linkages between categories could then make. Speculative inferences and summarising data formed the findings after which negative cases were sought. Theorising then took place, an interpretation of the results to understand meaning (Hinchey, 2008). As Hinchey (2008) asserts, action research is interpretivist, and judgements were made based on the researcher’s experience to offer a reading of the data. Analysis of each workshop took place immediately after completion, being coded and analysed in NVivo (a computer programme for qualitative data analysis). As new data were added following each workshop, this was assimilated into the data set which was then recoded. Writing up occurred throughout the process. This was written as a narrative recording reflections and observations from each workshop and subsequent outcomes. The writing acted as a form of analysis which was cross-checked against the collected and coded data. An example of coded data is provided in Table 5.

**Table 5. Example of coding.**

| Domain                  | Category                   | Code                        | Raw data                                                                                                                                                                                                 |
|-------------------------|----------------------------|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Use of the framework    | Mapping process            | Plotting activity changes   | When you were talking about plotting yourself on the grid and then plotting precedents, architects and technologies and then you look around and find something you’re interested in and it starts pulling you over in certain ways and it’s a driver to consider you’re approach to sustainability. (feedback from workshop 2) |
|                         |                            | sustainable approach        |                                                                                                                                                                                                         |
|                         |                            | Plotting activity changes   | Mapping precedents aiding design process                                                                                                                                                                  |
|                         |                            | sustainable approach        | Plotting activity changes                                                                                                                                                                              |
|                         |                            | sustainable approach        | Mapping precedents aiding design process                                                                                                                                                                 |
|                         |                            | sustainable approach        | Plotting activity changes                                                                                                                                                                              |
| Practice at centre of map |                            | Plotting activity changes   | Plotting activity changes                                                                                                                                                                              |
| Practice at centre of map |                            | sustainable approach        | Plotting activity changes                                                                                                                                                                              |
| Practice at centre of map |                            | sustainable approach        | Plotting activity changes                                                                                                                                                                              |
Validity

Credibility was achieved through prolonged engagement with the environment in order to learn the culture (Lincoln & Guba, 1985). The primary means of validation was through member checks (validating data with participants) (Lincoln & Guba, 1985; Oliver-Hoyo & Allen, 2006) in the validation interviews. Tactics to ensure the honesty of participants were employed such as making clear to participants that they were able to be frank and open without influencing their academic studies (Shenton, 2004). The researcher’s position as an academic and teacher not directly involved in the delivery of their course helped enable this.

Lincoln and Guba (1985) refer to transferability as the ability for the data to be generalizable and externally valid. This was achieved through a thick description of the research which allows for alternative conclusions and the possibility of application to other contexts (Lincoln & Guba, 1985). The accumulation of similar studies across a range of contexts might enhance the transferability and the potential generation of theory (Shenton, 2004).

Results

Sustainable concepts in the design studio

Student attitudes towards sustainable design and its integration into the design studio were key themes of the sessions. In the first workshop, some participants felt that traditional architectural teaching environments did not provide space for wider conceptual thinking on sustainability. When referring to feedback from tutors on sustainable strategies in their design project, one student put it:

“In the crit situation it’s very difficult to have a back and forth interrogation with the critics. Someone might just say that doesn’t work … or there will be a design tutor who will almost take your word for it”. (Participant B, workshop 1)

The group suggested an alternative teaching environment beyond the design studio might allow critical and reflective thought. Suggestions included a sustainably focussed crit or conference style teaching environments.

In the second workshop, the inadequacy of the design studio as a forum for both sustainability and design was corroborated. The focus on developing a personal project restricted student interest to aspects of environmental measures they perceived as directly relevant to their design projects. Furthermore, it became clear there was a perceived incompatibility between good design and sustainability. This was supported by the findings of the third workshop, in which participants struggled to relate ‘non-sustainable’ precedents to the framework and describing how only ‘eco’ exemplars could embody ideas about sustainable design.

“I thought about my precedent but generally it’s not a good environmental building at all so where would you put it? This model is just about environmental types.” (Participant C, workshop 3)

The division between teaching for design and teaching for sustainability was apparent in the fourth session, in which participants described how they were unable to translate
sustainable concepts into concrete designs. Often there was a misuse of terminology and lack of conceptual clarity. For example, the relationship between the environmental control of buildings (referring to the management of the internal environment) and environmental sustainability were often used interchangeably by participants:

“The confusing thing for me was my project was more about sustainability but then there was the environment thing which I hadn’t really thought about a specific strategy.”
(Student A, workshop 4)

**Exposure to perspectives**

The findings revealed how participants perceived a lack of exposure to varied perspectives and outlooks, from both the teaching staff and the nature of architectural precedents that were advocated. In the first workshop, participants expressed a desire for exposure to radical and alternative ways of thinking beyond the accepted and conventional content of their sustainable education. They described how examples of sustainable architecture used by educators lacked wider architectural merit beyond their environmental credentials and implicit sustainable construction was often neglected in favour of overtly ‘green’ buildings. There was a desire to be exposed to precedents that integrated sustainability within schemes of high architectural merit.

“I can think of quite a few [examples of sustainable buildings] but they’re all ugly!”
(Participant E, workshop 1)

The group also highlighted the need for knowledgeable experts and consultants to be involved in studio teaching. There was a perceived lack of personal skills and access to tools for analysis and assessment of sustainability in the design process.

In the second workshop, the group spoke about their limited access to alternative or contradictory approaches to sustainability in their education. An applied technical approach was considered the dominant paradigm in the design studio.

“At undergrad only eco-technic was really ever explored and talked about. We were not taught about the others and it’s only really through working in practice or doing my own thing that I realised there are other approaches [to sustainability] than just bling.”
(Participant R, workshop 2)

By the third workshop participants discussed various competing notions of sustainable design accepting that there may be multiple approaches to sustainable issues. A number of members expressed critical attitudes to specific strategies (including vertical farming and nuclear power stations). Others, however, did not consider sustainability as a value driven. One participant considered sustainability as contextual and not linked to any particular set of political values:

“I don’t think it depends on what we think – we may think it’s all of those but it’s got to be relevant to the project.” (Participant M)

**Critical interactions with sustainable content**

The process of developing a critical framework encouraged critical interactions with sustainable design from participants. For example, in the second workshop, an axis was
presented based on that defined by Dusch et al. (2010) onto which sustainable paradigms described by Guy and Farmer (2001) were plotted approximately (see Figure 2). The group stated how they felt under pressure to take a technical approach to sustainable design in the design and required a mechanism to legitimise alternative approaches.

“You feel the need to show bling in project work however if you can categorically say ‘I’m at this end’ and there are categories you can then really focus on doing whatever you need to do and not focus on things that are high tech.” (Participant A, workshop 2)

This directly led to the development of a framework presented in the third session which proposed a multi-directional axis which challenged the assumption of optimal techno design solutions, conceiving sustainable design as a balance between competing, and often contradictory, value systems (see Figure 3).

The eco-logics were redefined to describe a series of ideal typologies. Yet rather than adding conceptual clarity to the debate, participants found it challenging to relate to the conceptual abstraction of the framework. For example, in the third workshop, in which the framework was presented to participants, they were unable to articulate assumptions made by each of the positions on the model.

In the fourth workshop however, an active mapping exercise was used based around a loosely structured framework. Participants named strategies and placed them on the framework, stimulating further critical discussion surrounding each approach. The group identified categories of comparable ideas and named them (tick-box environmental add-ons, easily criticised holistic, large scale, small scale, true sustainability) which allowed them to identify assumption embedded within each strategy as well as critique their value (Figure 4 and redrafted in Figure 5 for legibility).

Figure 4. Workshop 4 mapping exercise redrafted.
Through this restructuring of prior knowledge, participants were able to critically analyse the various strategies plotted. One student described how the framework showed how some strategies were valid approaches while others were ‘tick box’ exercises:

“This project I have done much more of that stuff in the top left [of the framework] but this is where they get confused with environment. Top left [of the framework] is more about sustainability whereas environment is the bottom/middle which is a tick box exercise.” (Participant A, workshop 4)

**Relating to experiences and prior knowledge**

In the workshops participants could analyse and question their own prior knowledge as well as objectively reflect upon previous design work. The delivery and structure of the workshops was seen to be directly linked to the level of engagement and perceived value of the framework. In workshops 2 and 3, the framework was presented as a finished product, which was then used as a vehicle for discussion. Participants were able to critically assess real-world case studies especially when drawing from personal experience however could not contextualise these in terms of alternative approaches:

“We designed a pool for a rich person using so much stone that it has to be quarried over 2 years. They claim to be sustainable!” (Participant E, workshop 3)
In workshop 4, participants preferred using the matrix as a structure as it allowed ideas to ‘overlap’ while predefined typologies presented in earlier workshops were considered limiting. The ambiguity of defining what constitutes high-tech, low-tech, active engagement or passive engagement provided stimulus for the group to critique their strategies.

**Participant A:** I could definitely place my project. It’s low tech and highly [socially] active.

**Participant R:** I would say yours is high tech and socially active. It’s underground!

**Participant A:** I suppose in terms of its construction. So in use its one side and operation it’s the other side . . . more long-term its low-tech.

(Participants A and R, workshop 4)

Through attempting to position their project on the framework, A was able to enter into a dialogue with R and question his own work revealing the potential impact of previously unconsidered aspects of his scheme (the fact it was underground). This was reflected in the validation interviews conducted at the end of the research. While set typological categories were rejected, some participants felt the addition of tangible case studies, plotted on the matrix, might be helpful. Through comparison they could relate their projects to a wider architectural context as well as providing a framework for knowledge extraction from exemplar schemes.

The whole graph thing if you were to take a step further would be to tie it with case studies so you know at this side of the graph that aspect of sustainability you can see what it relates to give it a clearer picture. (Participant H, validation interview)

This helped participants reflect on their own understanding of sustainable design and their own learning.

“It was also easier with the grid to see where our knowledge was lacking because you can see whether things are high-tech or social and may reveal a knowledge gap more than having predefined categories.” (Participant A, validation interview)

### Restructuring of information and application of sustainable concepts

The critical framework evolved throughout the workshops in response to the first session in which participants described how they lacked the specific tools in the design studio to adequately apply sustainable concepts. The active approach taken in workshop 4 directly restructured participants own knowledge and allowed them to draw logical conclusions from trends apparent in the framework.

**Participant K:** There is definitely a trend that runs from top left to bottom right.

**Participant A:** I agree. Although if we are talking about reusing renewable materials you have to be able to convince the contractor as it won’t be off the peg, it won’t be standard. It takes a lot of active engagement to do that. So maybe some of the high tech ones still need that.

(Participants K and A, workshop 4)
Participants questioned how cost might affect the mapping exercise, considering it to be the driving force behind sustainability in commercial situations and asked whether it might be incorporated into a redesign of the framework.

“I think it would be replotted against cost. Not necessarily different positions but they might take priority for example blinds over more expensive shading techniques.” (Participant A, workshop 4)

In validation interviews, participants found the framework helpful to reveal where knowledge was lacking through contextualising their ideas in this manner. They described how they were internally relating back to the framework to categorise and structure their own thinking (participant H) and to synthesise new ideas. It was considered helpful to clarify internal narratives and approaches to sustainability, combatting ‘the cloud of different ideas’ (participant A) that constitute sustainable design. Participants described how the framework had given them understanding of alternative sustainable approaches:

“The [framework] was the most successful thing in my mind to show where buildings can sit and still be sustainable without being super high tech with wind turbines and stuff.” (Participant A, validation interviews)

However, they expressed concerns that they might ‘type cast’ themselves and as such any framework would have to be specific to projects, not individuals.

Reflecting on the workshops they were deemed most successful when participants actively engaged in the sessions. As participant A suggested, it was helpful to see that is ‘how you use it’. Many suggested a workshop approach, similar to that undertaken in Workshop 4 might be beneficial instead of traditional, student-led tutorials.

“You could do it less tutorial focussed where we’re asking you questions and it’s more forced to get everyone round the table to discuss sustainability. And we can really focus on the main bits rather than present the ideas that we’ve already got to you. We as group can talk about the issues.” (Participant A, validation interview)

**Discussion**

The aim of the research was to enhance deep learning for sustainability through developing a critical tool. Beattie, IV et al. (1997) defines the characteristics of deep learning as being able to interact critically with content, to relate this to personal experiences and to draw these to logical conclusions. All three activities were observed in the workshop sessions. In workshops 2 and 3, the framework was used to interpret and critique precedent examples while in the third workshop, the structure enabled a discussion that drew from participant’s personal experiences and political viewpoints. In workshop 4, it allowed specific sustainable design strategies to be mapped and trends revealed. This demonstrated the strength of the framework as a tool for promoting critical and reflective conversation in which students actively sought to uncover the underlying meaning behind sustainable design strategies.

Despite mapping the *eco-logics* of Guy and Farmer (2001) to the framework, without significant explanation it remained too abstract for many participants. Concrete precedent examples allowed a way in to the framework for participants however it was of most value was when they drew from their own experiences to create and engaging with
the framework. This process of co-creation encouraged participants to analyses strategies and reveal underlying assumptions and meaning, prompting critical conversation aligning with the aims of deep learning (Marton & Säljö, 1976).

The impact of the framework on design studio activities described by some participants suggests its potential as a tool to structure deep learning from the questioning of underlying assumptions to clarifying strategies through logical analysis (Beattie, IV et al., 1997). Students described how it clarified their thinking as well giving them confidence to adopt particular design approaches.

The workshops acted as a vehicle for critical analysis of sustainable design through providing a structure for comparing and debating sustainable strategies. Reflecting on the outcomes of the research the framework was more effective even without formal definition of the axes or associated typologies. Drawing from concept mapping methodologies (Novak & Cañas, 2006) created a valuable reflective tool for critically comparing sustainable strategies. This encouraged active participation and knowledge co-creation engendered a greater sense of ownership of the framework and participants were able to demonstrate critical analysis of ideas.

The design of the framework was based on diagrammatic representations of sustainable innovation, notably that defined by Dusch et al. (2010) however it was developed by continuous feedback over the course of the ESDAG. This development led to a re-construction of the framework as multi-directional in which all approaches may be considered equally valid aligning with a pluralist interpretation of sustainability. The findings highlight the importance of creating space beyond the design studio in which students can reflect upon their own practice. Through extending the bounds of architectural education, as well as enabling environments in which professional and academic practice can be challenged, innovative thinking and deep learning can flourish. The success of a formal workshop style workshop questions the hegemony of the traditional desktop crit or tutorial which are unstructured and student-led (Goldschmidt, Hochman, & Dafni, 2010). The alternative presented here allowed students to generate new and diverse knowledge, beyond the scope of the traditional tutorials, which could both enhance studio work and foster deep learning through reflection-on-action (Schön, 1984). In validation interviews, participants stated a workshop-like environment would be beneficial in addition to the traditional studio in which sustainable issues could be discussed and challenged. This supports the provision of alternative complementary environments to the design studio, such as the second studio concept (Allen, 1997), which serve to encourage a more complete experiential learning cycle (Kolb & Goldman, 1973).

Conclusion

The original reflective framework was used as a means to structure conceptual sustainable design information. It was developed due to a need for deep learning for sustainability in the design studio. The framework differs from existing sustainable design and development models in its specificity to architecture. Although previous analyses of sustainable architecture have generated similar typological categorisations (Guy & Farmer, 2001), they do not structure these into a comparative framework. Furthermore, the participatory formation of the framework enhances its capacity to act as a tool for empowering actual changes in participants’ own design practice.
The workshops highlighted the importance of knowledge co-creation as a means for deep learning. Top down definitions of sustainable design typologies required explanation and didactic teaching methods which limited student engagement and understanding. Using a simple structural device through which participants could map their own knowledge allowed the formation of shared visualisations which enhanced understanding and enabled critical analysis. The combination of this structured framework and the collaborative nature of the workshops were crucial to success.

A complimentary learning environment to the design studio provided a student-centred approach to sustainable design. This contrasts with traditional teaching in the design studio which is typically based on individual student/tutor interactions and intuition (Webster, 2004). Intermediary learning environments have the potential to contribute directly to the design studio, by allowing critical analysis of individual design ideas. Yet, by operating outside the design studio, the workshops were not subject to its embedded cultural norms. This offers an alternative to the traditional dichotomy of the design studio and satellite modules, the favoured method for teaching sustainable design (Altomonte, 2009).

Beyond architectural education, the framework provides a tool for contextualising sustainable design approaches in all disciplines which adopt a studio pedagogy. Through mapping designs strategies and comparing their technological characteristics with their social implementation, critical discussions can be facilitated which ultimately encourage deep and reflective learning. Other disciplines can also draw from a PAR methodology by creating a community of students willing to engage in participatory transformative action. This will yield specific tools for empowering critical understandings of sustainability.

In the context of UK architectural education, similar approaches to learning for sustainable design offer opportunities to go beyond the requirements of professional accreditation (provided by the Royal Institute of British Architects). At both undergraduate and post-graduate level, requirements emphasise ‘knowledge’ and ‘understanding’ (Royal Institute of British Architects, 2010). From this criteria, the common curriculum of semi-integrated satellite modules has developed which may limit deep learning. Requiring a critical approach may encourage the creation of alternative learning environments beyond the traditional studio.

The research was limited by its focus on a single school of architecture however the ‘thick’ description provided allows a degree of transferability to other similar contexts. The reliance on the active participation of members of the ESDAG became problematic in the later stages of the project where deadlines and external pressures limited enthusiasm and participation.

The research highlighted the need to address the division between sustainability in theory and in practice. The independence of the sessions from the design studio allowed the creation of a reflective critical environment, yet its impact on individual design processes is less clear. Further iterations of the study may examine whether the workshops alter actual practice in the design studio. The operation of the proposed framework and participatory methodology in a range of architectural education institutions and pedagogies could also be examined to enhance transferability.
Disclosure statement

The authors were employees at the case study university.

Data Accessibility

Data can be made available by the authors upon request.

Funding

This work was supported by the Engineering and Physical Sciences Research Council [EPSRC-ENG-DTA].

ORCID

Robert Grover http://orcid.org/0000-0002-3096-739X
Stephen Emmitt http://orcid.org/0000-0002-8277-3378
Alex Copping http://orcid.org/0000-0002-7276-0936

References

Allen, E. (1997). Second studio: A model for technical teaching. *Journal of Architectural Education, 51*(2), 92–95. doi:10.1080/10464883.1997.10734756

Altomonte, S. (2009). Environmental education for sustainable architecture. *Review of European Studies, 1*(2), 12. doi:10.5539/res.v1n2p12

Altomonte, S., Attia, S., Herde, A., & Dartevelle, O. (2010). EDUCATE state of the art of environmental sustainability in academic curricula and conditions for registration. Retrieved from Nottingham: www.educate-sustainability.eu.

Banham, R. (1991). A black box: The secret profession of architecture. *New Statesman and Society, 3*, 22–25.

Bashier, F. (2014). Reflections on architectural design education: The return of rationalism in the studio. *Frontiers of Architectural Research, 3*(4), 424–430. doi:10.1016/j.foar.2014.08.004

Beattie, IV, V., Collins, B., & McInnes, B. (1997). Deep and surface learning: A simple or simplistic dichotomy? *Accounting Education, 6*(1), 1–12. doi:10.1080/096392897331587

Biktimirov, E.N., & Nilson, L.B. (2006). Show them the money: Using mind mapping in the introductory finance course. *Journal of Financial Education, 32*, 72–86.

Brand, R., & Fischer, J. (2013). Overcoming the technophilia/technophobia split in environmental discourse. *Environmental Politics, 22*(2), 235–254. doi:10.1080/09644016.2012.730264

Brookfield, S.D. (1997). Assessing critical thinking. *New Directions for Adult and Continuing Education, 1997*(75), 17–29. doi:10.1002/(ISSN)1536-0717

Brydon-Miller, M., Greenwood, D., & Maguire, P. (2003). Why action research? *Action Research, 1*(1), 9–28. doi:10.1177/14767503030011002

Buckingham-Hatfield, S., & Evans, R. (1996). *Sustainability and planning*. Chichester: John Wiley and Sons.

Ceschin, F., & Gaziulusoy, I. (2016). Evolution of design for sustainability: From product design to design for system innovations and transitions. *Design Studies, 47*, 118–163. doi:10.1016/j.destud.2016.09.002

Clune, S. (2014). Design for sustainability and the design studio. *Fusion Journal, 3*, 1–16.

Cohen, L., Manion, L., & Morrison, K. (2000). *Research methods in education*. (5th ed.). London: Routledge Falmer. *Teaching in Higher Education,41.*
Cook, S.J., & Golton, B. (1994). Sustainable development concepts and practice in the built environment – A UK perspective. Paper presented at the First Int. Conference of Sustainable Construction, Tampa, FL.

Crysler, C.G. (1995). Critical pedagogy and architectural education. Journal of Architectural Education, 48(4), (1984–), 208–217.

Davies, M. (2011). Concept mapping, mind mapping and argument mapping: What are the differences and do they matter? Higher Education, 62(3), 279–301.

Douvlou, E. (2006). Effective teaching and learning: Integrating problem-based learning in the teaching of sustainable design. CEBE Transactions, 3(2), 23–37.

Dusch, B., Crilly, N., & Moultrie, J. (2010). Developing a framework for mapping sustainable design activities. Paper presented at the DRS International Conference: Design & Complexity, Montreal, Canada.

Dutton, T.A. (1991). Voices in architectural education: Cultural politics and pedagogy. New York: JF Bergin & Garvey.

EDUCATE. (2012). Sustainable architectural education: White paper. Retrieved from Nottingham: https://www.educate-sustainability.eu/kb/

Entwistle, N.J. (2013). Styles of learning and teaching: An integrated outline of educational psychology for students, teachers and lecturers. London: Routledge.

Fenner, R.A., Ainger, C.M., Cruickshank, H.J., & Guthrie, P.M. (2005). Embedding sustainable development at Cambridge University engineering department. International Journal of Sustainability in Higher Education, 6(3), 229–241.

Gelernter, M. (1988). Reconciling lectures and studios. Journal of Architectural Education, 41(2), 46–52.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). The new production of knowledge: The dynamics of science and research in contemporary societies. London: Sage.

Glaser, B.G., & Strauss, A.L. (2009). The discovery of grounded theory: Strategies for qualitative research. New Jersey: Transaction Publishers.

Goldschmidt, G., Hochman, H., & Dafni, I. (2010). The design studio “crit”: Teacher–Student communication. Artificial Intelligence for Engineering Design, Analysis and Manufacturing, 24(03), 285–302.

Gürel, M.Ö. (2010). Explorations in teaching sustainable design: A studio experience in interior design/architecture. International Journal of Art & Design Education, 29(2), 184–199.

Guy, S., & Farmer, G. (2001). Reinterpreting sustainable architecture: The place of technology. Journal of Architectural Education, 54(3), 140–148.

Guy, S., & Moore, S.A. (2007). Sustainable architecture and the pluralist imagination. Journal of Architectural Education, 60(4), 15–23.

Hajer, M., & Versteeg, W. (2005). A decade of discourse analysis of environmental politics: Achievements, challenges, perspectives. Journal of Environmental Policy & Planning, 7(3), 175–184.

Hannigan, J. (2014). Environmental sociology. London: Routledge.

Hassanpour, B., Alpar Atun, R., & Ghaderi, S. (2017). From words to action: Incorporation of sustainability in architectural education. Sustainability, 9(10), 1790.

Hemsath, T.L. (2017). Is architectural pedagogy prepared for buildings of the future? Journal of Solar Energy Engineering, 139(1), 0110031–0110039.

Hinchey, P.H. (2008). Action research primer. New York: Peter Lang.

Hopwood, B., Mellor, M., & O’Brien, G. (2005). Sustainable development: Mapping different approaches. Sustainable Development, 13(1), 38–52.

Howlett, C., Ferreira, J.-A., & Blomfield, J. (2016). Teaching sustainable development in higher education: Building critical, reflective thinkers through an interdisciplinary approach. International Journal of Sustainability in Higher Education, 17(3), 305–321.

Jackson, T., & Ravetz, J. (2000). City region 2020: Integrated planning for a sustainable environment. London: Earthscan.
Jamison, A. (2001). The making of green knowledge: Environmental politics and cultural transformation. Cambridge: Cambridge University Press.

Jepson, E.J. (2004). Human nature and sustainable development: A strategic challenge for planners. CPL Bibliography, 19(1), 3–15.

Kolb, A.Y., & Kolb, D.A. (2005). Learning styles and learning spaces: Enhancing experiential learning in higher education. Academy of Management Learning & Education, 4(2), 193–212.

Kolb, D.A., & Goldman, M.B. (1973). Toward a typology of learning styles and learning environments: An investigation of the impact of learning styles and discipline demands on the academic performance, social adaptation and career choices of MIT seniors. Cambridge, Mass.: Massachusetts Institute of Technology.

Lincoln, Y.S., & Guba, E.G. (1985). Naturalistic inquiry (Vol. 75). London: Sage.

Marton, F., & Säljö, R. (1976). On qualitative differences in learning: I—Outcome and process. British Journal of Educational Psychology, 46(1), 4–11.

McAllister, K. (2010). The design process-making it relevant for students. International Journal of Architectural Research, 4(2–3), 76–89.

McClean, D. (2009). Embedding learner independence in architecture education: Reconsidering design studio pedagogy. (Doctoral dissertation), Robert Gordon University, Aberdeen.

McIntyre, A., Chatzopoulos, N., Politi, A., & Roz, J. (2007). Participatory action research: Collective reflections on gender, culture, and language. Teaching and Teacher Education, 23(5), 748–756.

Novak, J.D., & Cañas, A.J. (2006). The origins of the concept mapping tool and the continuing evolution of the tool. Information Visualization, 5(3), 175–184.

O’Riordan, T. (1989). The challenge for environmentalism. New Models in Geography, 1, 77.

Oliver-Hoyo, M., & Allen, D. (2006). The use of triangulation methods in qualitative educational research. Journal of College Science Teaching, 35(4), 42–47.

Olweny, M. (2018). Introducing sustainability into an architectural curriculum in East Africa. International Journal of Sustainability in Higher Education, 19(6), 1131–1152.

Patton, M.Q. (1980). Qualitative evaluation methods. Beverly Hills, Ca: Sage.

Pearce, D.W. (1993). Blueprint 3: Measuring sustainable development (Vol. 3). London: Earthscan.

Piaget, J. (1971). Structuralism. (C. Maschler & C. Maschler, Ed). London: Routledge and K. Paul.

Reason, P., & Bradbury, H. (2008). Introduction to groundings. In P. Reason & H. Bradbury (Eds.), The SAGE handbook of action research: Participative inquiry and practice. London: SAGE, (pp. 11-14).

Rogers, R.R. (2001). Reflection in higher education: A concept analysis. Innovative Higher Education, 26(1), 37–57.

Royal Institute of British Architects. (2010). RIBA validation criteria at part 1 and part 2. London: RIBA.

Schön, D.A. (1984). The reflective practitioner: How professionals think in action (Vol. 5126). New York: Basic books.

Schön, D.A. (1985). The design studio. London: RIBA Publications Ltd.

Shenton, A.K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. Education for Information, 22(2), 63–75.

Symons, J., & Karlsson, R. (2015). Green political theory in a climate-changed world: Between innovation and restraint. Environmental Politics, 24(2), 173–192.

Till, J. (2003). Lost judgement. EAAE Prize, 2005, 164–181.

Tischner, U., & Verkuil, M. (2006). Design for (social) sustainability and radical change. Paper presented at the perspectives on radical changes to sustainable consumption and production, Copenhagen.

Trochim, W.M.K. (1989). An introduction to concept mapping for planning and evaluation. Evaluation and Program Planning, 12(1), 1–16.

Twardy, C. (2004). Argument maps improve critical thinking. Teaching Philosophy, 27(2), 95–116.
Vezzoli, C.A., & Manzini, E. (2008). A new conceptual framework for sustainable development design for environmental sustainability. London: Springer Science & Business Media.

Warburton, K. (2003). Deep learning and education for sustainability. International Journal of Sustainability in Higher Education, 4(1), 44–56.

Webster, H. (2004). Facilitating critically reflective learning: Excavating the role of the design tutor in architectural education. Art, Design & Communication in Higher Education, 2(3), 101–111.

Wenger, E. (2000). Communities of practice and social learning systems. Organization, 7(2), 225–246.

Whyte, W.F. (1991). Participatory action research. Newbury Park, Calif.: Sage Publications Inc.

Winn, W. (1991). Learning from maps and diagrams. Educational Psychology Review, 3(3), 211–247.

Zuber-Skerritt, O. (1996). Emancipatory action research for organisational change and management development. In O. Zuber-Skerritt (Eds.), New directions in action research. London: Falmer Press, (pp. 83–105).