Enhancing Knowledge Management in Design Education Through Systematic Reflection Practice

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CE CONCURRENT ENGINEERING: Research and Applications

Enhancing Knowledge Management in Design Education Through Systematic Reflection Practice

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Abstract: The significant role of reflection in sustaining the quality of learning and teaching (L&T) activities at high levels has been widely acknowledged in literature. Reflection has been identified as a key factor underpinning both successful learning by students and successful continuing professional development by their teaching staff in higher education. This study focuses on aspects associated with the individual reflection practice of teaching staff. It is proposed and maintained that the establishment of systematic reflection practice has a central role in enhancing knowledge management in design education. To this end, the consistency and coherence, in which key perspectives of reflection are considered and evidenced by teaching staff, need to be both ensured and sustained. Reflection Space is introduced as an approach to support the establishment of systematic[1], evidenced[2], and traceable reflection practice. It is a means of representing the nature, or perspectives, of reflection required on L&T and it has been applied and evaluated to a number of L&T contexts. An application of Reflection Space is demonstrated through a case study that dealt with the development of a Design Studio module delivered to Year 2 Product Design students. Evaluation of the application has shown that use of Reflection Space during the reflection phase of L&T activities can ensure that key reflective perspectives of L&T have been considered and evidenced. As a result, actions for the enhancement and/or improvement of the deployed L&T activities can be determined in a systematic, evidenced, and traceable manner.

Key Words: reflection space, evidencing reflection, learning and teaching, design studio.

1. Introduction

Reflection has been identified as a key factor underpinning both successful learning by students and successful continuing professional development by their teaching staff in higher education. For example, Forsyth et al. [1] highlight that the demand for quality assurance in today's educational climate calls for maintaining credibility through consideration not only of the learners and what they have achieved, but also through consideration of the effectiveness and efficiency of the teaching staff's actions and the learning taking place. To this end, reflective practice should be a central activity of staff involved in learning and teaching (L&T) activities. Establishment of systematic reflection practice can enhance both the evaluation of a module, or course, and the derivation of corresponding corrective, or improvement, actions [1–3].

1.1 Aim and structure of the study

This study discusses the value of reflection in enhancing knowledge management in higher education and aims to support teaching staff in design education during their reflection practice. It is maintained throughout the study that central to effective reflection practices should be the use of approaches or tools that can ensure consistency in the way in which key perspectives of reflection are considered and evidenced. The remainder of the study is structured as follows. Section 2 outlines the research methodology used. Section 3 elaborates on the significance of evidencing reflection to enhance knowledge management in higher education and discusses benefits and challenges in evidencing reflection in higher education. Section 4 discusses the particular link between reflection and design education in enhancing knowledge management practices. Reflection Space is introduced as an approach to support practical, efficient, and meaningful reflection practice. Section 5 describes an application of Reflection Space to an analysis and evaluation of the design process of a Design Studio module, and discusses such application. Finally, Section 6 presents the conclusions drawn.

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Figure 1 appears in color online: http://cer.sagepub.com
[1] In this study, systematic refers to both the order of the activities carried out and the timing that such activities take place.
[2] The term 'evidenced' is used in this study to refer to activities involved in purposefully collecting and documenting L&T data by a way of providing proof on claims and decisions made, and/or actions taken.

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2. Research Methodology

This section gives a summary of the research methodology used. Action research constitutes the kernel of the research methodology, enhanced with contributions from hypothesis-testing and case study based methodologies [4,5]. Figure 1 shows the three key elements of the research methodology: (i) the research framework, (ii) the real-world problem situation, and (iii) the structured experience. The above elements are linked through a number of relationships that are listed here and depicted in Figure 1.

- *evaluate in* – is the application of the research framework to a real-world problem situation; this sets the context for evaluation through elicitation and documentation of evidence.
- *extract* – is the elicitation and documentation of evidence from the real-world problem situation;
- *inform* – is the dissemination of new learning to the real-world problem situation;
- *improve* – involves the refinement of the research framework.

The methodology set the basis for the completion of a series of process cycles that led to the research results reported in this study[3]. The article has been structured around the elements of the research methodology. Sections 3 and 4 detail the research framework (e.g., literature on reflection practice and the introduced approach of Reflection Space). Section 5 describes the real-world problem situation and details the structured experience and inform elements (e.g., application and evaluation of Reflection Space to the design process of a Design Studio module). Section 6 presents the conclusions drawn and as such relates to the improve element of the research methodology (see Figure 1).

3. Evidencing Reflection in Higher Education

Knowledge management is such a wide-open area of study that it is difficult to understand its implications for educational settings [8]. According to Kidwell et al. [9] higher education institutions have 'significant opportunities to apply knowledge management practices to support every part of their mission'. Key to this is an understanding of knowledge management practices as

[3] Checkland and Holwell [6] emphasized the importance of the notion of recoverability in action research as opposed to that of repeatability, as a criterion for generalization and knowledge generation in natural science. That is, in action research, the researcher is after validation of the generated knowledge through explicitly presenting the research processes deployed and the research findings yielded in such a way that other parties would be able to follow the interpretation and conclusion of the researcher. Baskerville and Wood [7] also stated that 'action researchers can legitimately generalize their findings on the basis of the validity of their research'.

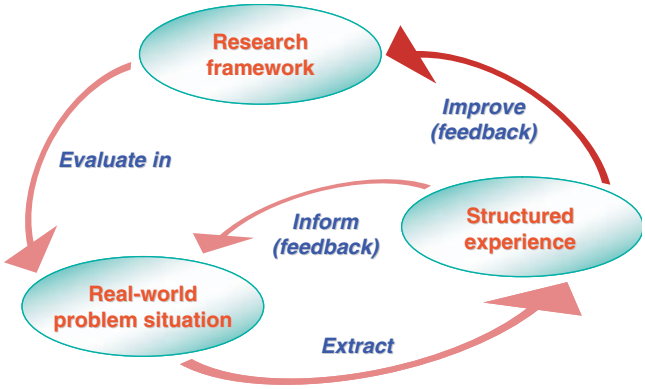

Figure 1. Abstract depiction of the research methodology process cycle.

applied at a corporate level. For example, Davenport et al. [10] conducted a study of 31 knowledge management projects across 24 companies and identified four generic types of objectives (listed below) that corporate knowledge management practices satisfy.

1. *Create knowledge repositories* through (a) external knowledge (e.g., competitive intelligence, market data, and surveys, (b) structured internal knowledge (e.g., reports, marketing materials, techniques, and methods), and (c) informal internal knowledge (e.g., discussion databases of 'know how' or 'lessons learned').
2. *Improve knowledge access* through (a) technical expert referral, (b) expert networks used for staffing based on individual competencies, and (c) exploitation of video conferencing to foster easy access to experts distributed around the globe.
3. *Enhance the knowledge environment* through (a) changing organizational norms and values related to knowledge in order to encourage knowledge use and knowledge sharing, and (b) asking customers to rate their provider's expertise.
4. *Manage knowledge as an asset* through attempting to measure the contribution of knowledge to bottom line success.

The call for improved knowledge management practices in higher education [9,10] has brought reflection into the center of an understanding of what professionals do and of how they might act to improve [11–14]. According to Schon [12] it is the ability to reflect both in, and on, action that can identify the effective professionals from the less effective ones. To this end, first, Section 3.1 gives background information on reflection and the act of reflecting, and then Sections 3.2–3.4 highlight the central role of the act of evidencing reflection as well as the challenges that need to be addressed toward enhancing knowledge management in higher education.

3.1 Reflection and the Act of Reflecting – the 'what' and 'how'

Reflection deepens learning [3,15,16]. Reflection could be argued to be the essential stage where learning is integrated within the whole learner, and added to existing frames of reference, and internalized and personalized. Reflection is equally useful when our learning has been unsuccessful – in such cases indeed reflection can often give us insights into what may have gone wrong with our learning, and how on a future occasion we might avoid now-known pitfalls. Most of all, however, it is increasingly recognized that reflection is an important transferable skill, and is much valued by all around us, in employment, as well as in life in general [17].

Reflection happens by posing questions to oneself, then attempting to answer them. The act of reflecting is one which causes us to make sense of what we have learned from what we did, why we learned it, and how that particular increment of our own learning took place. Moreover, reflection is about linking one increment of learning about our teaching to the wider perspective of learning – heading toward seeing the bigger picture both from our own point of view as teaching staff as well as from that of our students. Although many attempts to cause people to evidence their reflection tend to be backward-looking, the reflection which can be generated by past, present, and future-tense questions can be much deeper. For example, Table 1 gives a set of questions which is a much richer agenda for reflection than just any one of these questions on its own.

This set indicates that questions which aid deep reflection are rarely single questions, but tend to form clusters. There is often a starter question which sets the agenda, and frequently is a 'what?' question. Then come the more important ones – the 'how?' questions and the 'why?' questions – and sometimes the '... else?' questions which ask for even deeper thinking and reflection. In general, it seems too obvious to state it, but simple 'yes/no' questions can rarely enable the extent of reflection which can be prompted by more open-ended questions such as 'to what extent ...?'. Sadly, however, there remain far too many 'closed' questions on student feedback questionnaires, and unsurprisingly the level of student reflection that such questionnaires tend to elicit is limited [17].

Schon [12] suggests that there are two main types of reflection: reflection-in-action and reflection-on-action. Reflection-in-action occurs while an action is being undertaken – 'during which we can still make a difference to the situation at hand – our thinking serves to reshape what we are doing while we are doing it' [12]. Reflection-on-action, on the other hand, involves 'thinking back on what we have done in order to discover how our knowing-in-action may have contributed to an unexpected outcome' [12] or post-activity reflection on the activity. Bridger [18] emphasized the significance of reflection to organizational learning and development by introducing the concept of the so-called 'double task'. The underlying idea is that as well as being purpose-oriented, organizations have also to be learning and self-reviewing entities. The concept of the double task brings an activity task together with a reflective task and thus makes group members aware of both these aspects. Schon's and Bridger's models are in principle aligned to each other. However, one difference between the two models lies in the fact that Schon's model focuses on the timing of reflection (carried out either at individual or group settings) whereas Bridger's model focuses on the value of context in carrying out effective reflection in group settings (carried out either during or after the activity). In other words, the double task concept strongly relates to collective modes of reflection-in-action and/or reflection-on-action. The reported work relates to the reflection practice of teaching staff carried out at an individual basis; hence detailed analysis of the double task concept would be out of the scope of this study.

Van Manen [19] proposed three levels of reflection based on the work of Habermas [20]. The first level, technical reflection, deals with an analysis on the efficiency and effectiveness by which means are used to achieve given goals. The second, practical reflection, in addition to an analysis on the use of means, is concerned with an analysis of goals, the underlying assumptions and rationale of these goals, and the actual outcomes. The third level, critical reflection, in addition to the previous two, involves critical judgments on professional activity (e.g., being equitable, moral, respectful, and ethical) [21,22]. Schon's framework can incorporate all these three levels or kinds of reflection.

3.2 The Need for Evidence of Reflection

The ability to reflect is one of the most advanced manifestations of owning – and being in control of – a human brain. Have you reflected today? Almost certainly 'yes!' But have you evidenced your reflection

Table 1. A set of questions for reflection.

1. What worked really well for me?	4. What else happened to make it work well?
2. Why do I now think this worked well for me?	5. How best can I build on what went well?
3. What happened that made this work well for me?	6. What else am I going to do as a result of this having worked well for me?

today? Almost certainly 'sorry, too busy at the moment'. And the danger remains that even the best of reflection is volatile – it evaporates away unless we stop in our tracks to make one or other kind of crystallization of it – some evidence. In our busy professional lives, we rarely make the time available to evidence our ongoing reflection. But we are already into an era where our higher education systems are beginning to not only encourage, but also to require not only students but also teaching staff to evidence their reflection in the light of fostering knowledge use and dissemination [8,12,23]. So what can we do to address the reflection culture gap – how can we approach accommodating our lack of experience in evidencing our reflection, and helping our students to gain their skills at evidencing their reflection? Reflection is increasingly required in education and employment. More specifically, evidence of reflection is required, for example:

- where students are required to build up 'personal development planning' portfolios, or learning logs, or records of achievement, both as evidence to be able to present to prospective employers, and (more importantly) as a proactive process to help them to deepen their ongoing learning as it happens.
- where teaching staff are required (or encouraged) to build up records of their reflection on their developing work associated with teaching, learning, and assessment, so that they develop their practices in a more efficient and focused way than if they simply left reflection to chance;
- in most areas of professional life, where continuing professional development is required or expected, and where it is important at any stage to be able to show that such development is indeed being undertaken in an organized and professional way.

3.3 Benefits from Evidencing Reflection

Perhaps the most powerful advantage of evidencing reflection consistently and coherently is that it opens up the possibility for dialogue with significant others; for example, dialogue based upon evidenced reflection between:

- *Teachers and learners*, enabling learners to gain feedback on the quality and depth of their reflection, so that they are able to improve and develop both their reflection and their learning;
- *Staff developers and teachers*, enabling teachers to gain feedback on their own thinking about their triumphs and disasters alike, to enrich their own learning about their developing practice;
- *Appraisers and appraisees*, so that appraisal becomes a deeper and more meaningful process for both parties, allowing a greater depth of relevant discussion between them at appraisal interviews, and increased ownership of the appraisal agenda for appraisees.

The common ground among each of these three scenarios is the development of a greater sense of ownership, both of what has already been achieved, and what remains to be achieved. This sort of attitude is key to the development and implementation of effective knowledge management practices in higher education [9].

3.4 Challenges in Evidencing Reflection

Some professions have led the way regarding reflective practice, not least nursing and health care disciplines [24]. But for other disciplines, progress has been slower. Hard-nosed engineers, mathematicians, scientists, and business professionals have tended to shrug off reflection as subordinate to subject knowledge and skills. But the wider community beyond the campuses of higher education continues to value 'rounded' individuals, who can not only demonstrate subject knowledge and skills, but can develop and grow as circumstances around them continue to change and evolve [11,17].

The problem, in a nutshell, is that relatively few teachers in higher education have ever been asked to reflect. Many who enter the profession have been 'good' students – which boils down to successful students. But that does not necessarily mean they have had experience of – or indeed training in – how to evidence their reflection on their developing professional practice. For example, now that the UK higher education is evolving to embrace personal development plans by students, records of achievement, or 'progress files', the kind of reflection that students are required to undertake is beyond the personal experience of most of the staff who are requiring it. This is evidenced by the expressed difficulties that staff working towards L&T awards[4] are only too willing to admit to when they themselves are asked to evidence their own reflection on the learning they experience while working toward such awards [17]. In short, if teaching staff are not very skilled at reflecting, how on earth are they going to help our students to become skilled?

Teaching staff in higher education are not alone in often finding it hard to write about reflection on their professional practice. For example, in UK during the last two years or so, over 10,000 staff in higher education have been admitted to membership of the

[4] Note that new teaching staff entering the UK higher education are strongly encouraged, and in some cases even required, by their institutions to undertake formal L&T training, such as such Postgraduate Certificates in Teaching and Learning in Higher Education.

Higher Education Academy, and many remember that the hardest part of writing their applications was writing around 500 words about 'reflective practice and professional development'. Writing about the latter part was for most quite straightforward, as it boils down to presenting a little factual information about the staff development they have carried out in the last few years. But writing about 'reflective practice' is much harder for some, not least because the language of academe tends to be remote, formal, and scholarly, whereas the language of written reflection needs to be more personal and quite informal [12,17].

4. Reflection and Design Education

This section explains the particular link between reflection and design education in enhancing knowledge management practices. It relates to the research framework element of the research methodology presented in Section 2 (see also Figure 1).

A key competency that engineering and product designers are expected to develop is their ability to think laterally and be able to understand the whole picture [25,26]. This implies that engineering and product design students need to be trained accordingly; for example, to be able to define problems through understanding of the needs of significant stakeholders (e.g., users, consumers). This is necessary in order for their innovation and creativity efforts to be directed toward the development of products that address the identified needs.

There is overwhelming evidence that learning through doing is far more effective than learning through being told [27]. Central educational needs of engineering and product design students are these of using justifiable assumptions where information is incomplete and integrating a wide range of knowledge and skills (e.g., from the identification of user needs through to the realization of realistic physical prototypes) to specify, create, evaluate, and communicate workable product designs [28]. This explains why the majority of educational institutions offering design related courses have established Design Studios as an effective means to develop their students' design skills. It also suggests that although traditional methods may be desirable and effective for developing certain design awareness and skills (e.g., students getting acquainted with activities and processes involved in the design of products), these methods may not be the most appropriate for developing more advanced skills (e.g., students getting involved into the definition of a design problem and/or a product's brief, both of which support a holistic appreciation of the design problem they are trying to address).

A key characteristic of Design Studio sessions is that they enable and allow enriched interactions between both the teaching staff and the learners, and amongst the learners themselves. A key challenge for teaching staff leading Design Studio sessions is to evaluate their students' design activities. This is because design-related activities are open ended, and tutors cannot predict when, where, and what students are learning. Neither can tutors be specific with regard to their expectation about their students' learning experience because this is likely to be a combination of students' preconceptions, prejudices, and previous experiences. What students have learned from a design project, as well as what the tutors have experienced during the preparation and delivery of such project, can only be described in their own words [29]. Therefore, the effective completion of Design Studio sessions requires systematic, evidenced, and traceable reflection on the design activities carried out by both the students and the teaching staff. This is a pre-requisite for ensuring and safeguarding the quality of the delivered Design Studio sessions. Although a number of approaches and tools have been developed to support systematic, evidenced, and traceable student reflection practice (e.g., a learner's report [29] and a set of reflection questions [30]), similar approaches and tools to support the reflection practice of teaching staff are not widely available.

It is proposed and maintained in this study that an efficient way of helping teaching staff both to reflect and to evidence their reflection can be to provide them with approaches or tools that can serve as devices to help them to focus and direct their thinking to those areas of their work where reflection can pay highest dividends. Section 4.1 presents key L&T perspectives and demonstrates how to bring them into a single plane of reference to illustrate the range of reflection that should be encouraged.

4.1 Reflection Space: An approach to support meaningful reflection practice

The significant role of reflection in sustaining the quality of learning and teaching activities at high levels has been acknowledged by many authors [e.g., 12,13,30–32]. Central to effective reflection practices is the use of approaches that can ensure consistency in the way in which key perspectives of reflection are considered. To this end, *Reflection Space*™[5] [33], shown in Figure 2, is proposed as an approach to support the establishment of systematic, evidenced, and traceable reflection practice.

Reflection Space is a means of representing the nature, or perspectives, of reflection required on L&T.

[5] ©2005 by Vassilis Agouridas. All rights reserved. Reflection Space™ has been developed based on concepts presented in Thompson [34] and Agouridas et al. [35].

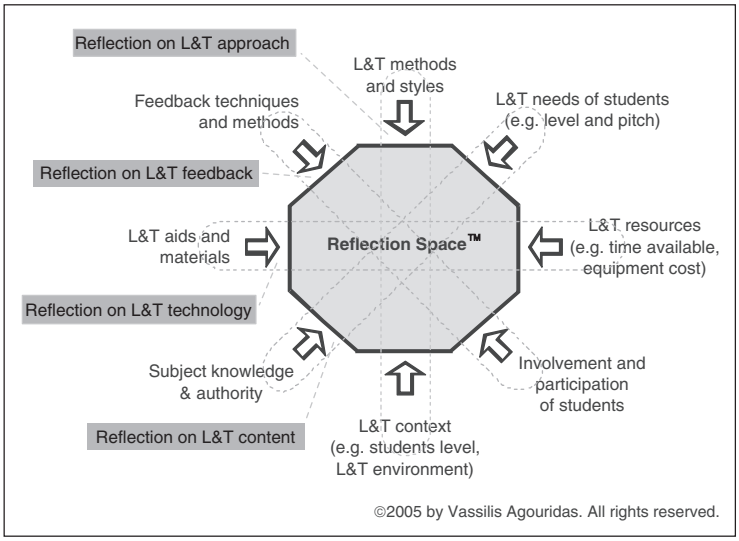

Figure 2. The characteristics of Reflection Space™ and its four key learning and teaching (L&T) reflection perspectives.

The represented perspectives are not exhaustive. Figure 2 shows four principal perspectives that need to be considered during reflection as they originate from the formation of four pairs. These four pairs provide a framework for reflecting on L&T activities in a holistic fashion. That is, they first bring to the attention of teaching staff key factors that could affect the effectiveness of L&T activities, and then they bring such factors together into a unique plane of reference. In this way, the risk of neglecting these factors, which may have previously been overlooked or even unarticulated on their potential effect on the quality of L&T activities, is minimized.

4.1.1 OPPORTUNITIES AND CONSTRAINTS IN REFLECTION SPACE

Each of the four pairs consists of two characteristics, or factors, and thus resulting in a total of eight key factors that support reflection practice. Figure 3 shows that these factors, which at a high-level can be classified either as opportunities or constraints, are topics of reflection practice that teaching staff should be encouraged to explore and integrate. The following list details these opportunities and constraints for each of the four pairs or L&T perspectives:

- classified as opportunities and constraints, respectively. This is because although teaching staff may have a number of methods and styles available to them (e.g., lectures and workshops; i.e., opportunities for delivery) selection of them should be justified by the context of L&T (e.g., students level and teaching room used; i.e., constraints on the delivery). During their reflection practice teaching staff can evaluate and evidence their experience with regard to the applicability, effectiveness, and appropriateness of the selected L&T methods and styles to the given L&T context.

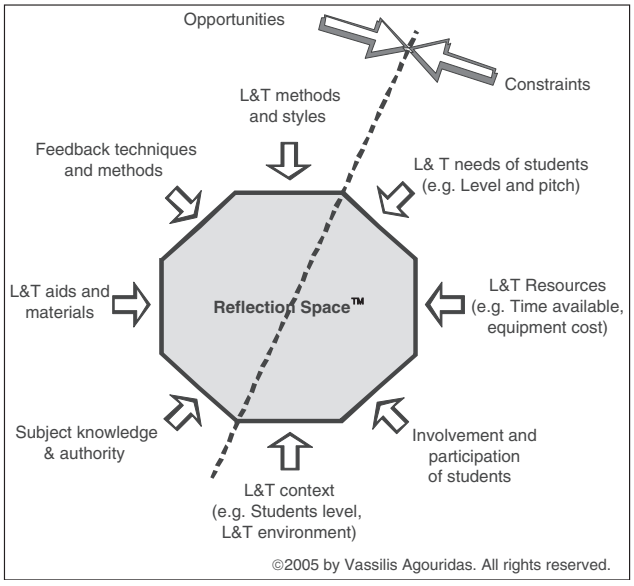

Figure 3. Opportunities and Constraints in Reflection Space™.

- *Reflection on L&T Feedback* – The factors of feedback techniques and methods, and involvement and participation of students are classified as opportunities and constraints, respectively. This is because although teaching staff may have a number of student feedback techniques and methods available to them (e.g., online feedback forms and informal chats; i.e., opportunities for obtaining feedback) selection of them should always be made on the basis of fostering students participation and involvement (e.g., students availability and timing of feedback; i.e., constraints on obtaining meaningful feedback from students). During their reflection practice teaching staff can evaluate and evidence their experience with regard to the degree in which the feedback methods used allowed the students not only

Table 2. Range of case studies carried out to evaluate application of Reflection Space.

Case study L&T area	Case study description	Details on module/level/ programme of study
Teaching	Large group lecture session	Introduction to design and manufacture/ Level 1/mechanical engineering
	Small group workshop session	Design Studio/Level 1/product design
Learning and assessment	Assessing student learning in the context of a product design studio module	Design Studio/Level 2/product design
Teaching with learning technology	Development and implementation of a learning technology in the context of a product design studio module	Design Studio/Level 2/product design
Managing and evaluating teaching	A problem-based learning approach to the design of a product design studio module	Design Studio/Level 2/product design

to participate but also to be involved in providing feedback comments.

- *Reflection on L&T Technology* – The factors of L&T aids and materials (technology), and L&T resources are classified as opportunities and constraints, respectively. This is because although teaching staff may wish to use certain technology to support their L&T activities (e.g., use of an electronic voting system; i.e., opportunities for using L&T aids) decisions on the acquisition and/or use of such technology should be justified by the available L&T resources (e.g., cost of ownership and/or use, and time required to develop or learn to use certain technologies; i.e., constraints on the use of L&T aids). During their reflection practice teaching staff can evaluate and evidence their experience with regard to the degree in which the used L&T aids and materials supported satisfaction of the defined L&T objectives while taking into account the resources involved in satisfying them. This is necessary in order to ensure the sustainable use of the selected L&T materials and aids.
- *Reflection on L&T Content* – The factors of subject knowledge and authority, and L&T needs of students are classified as opportunities and constraints, respectively. This is because although teaching staff may be recognized as experts in their subject area (e.g., internationally reputable and published; i.e., opportunities for disseminating cutting-edge knowledge) decisions on both the depth of the disseminated knowledge and its translation to L&T material should be justified by the identified L&T needs of students (e.g., L&T material pitched at the 'right' level and time; i.e., constraints on the dissemination of cutting-edge knowledge). During their reflection practice teaching staff can evaluate and evidence their experience with regard to the degree to which both the disseminated knowledge and the L&T material developed to disseminate this knowledge satisfied, and were aligned with, the L&T needs of the students. This is necessary in order to discourage the case of knowledge dissemination for the sake of knowledge dissemination; a case that could possibly be the aim of scientific journals but certainly not of L&T material.

Consideration of the above discussion as well as of Figures 2 and 3 indicates that application of Reflection Space during the reflection phase of L&T activities can ensure that key reflective perspectives of such activities have been sufficiently considered and evidenced. As a result, both the scope and specific actions for enhancement and/or improvement of the deployed L&T practice can be determined in a systematic and traceable manner.

5. Application of Reflection Space

This section presents an evaluation of Reflection Space that has been based on a number of case studies. It relates to the real-world problem situation, structured experience and inform elements of the research methodology presented in Section 2 (see also Figure 1). Table 2 outlines the case studies carried out to evaluate application of Reflection Space. It also outlines the key L&T areas as well as the curricula from which the case studies were drawn.

An application of Reflection Space through a case study drawn from the managing and evaluating teaching area (see Table 2) is detailed and discussed for the purposes of this study[6].

[6] The case study was developed by the first author of this article, and assessed by the second author and tutor (as well as all the other three tutors), as part of the first author's work towards a Postgraduate Certificate in Learning and Teaching in Higher Education (PGCLTHE) at the University of Leeds.

5.1 Description of the Application of Reflection Space against the Research Methodology

Sections 5.1.1 and 5.1.2 present the case study against the main elements of the research methodology described in Section 2. A discussion on the application of Reflection Space is given in Section 5.2.

5.1.1 REAL-WORLD PROBLEM SITUATION

The case study dealt with an analysis and evaluation of the design process of a Design Studio module and details how Reflection Space was applied to support such analysis and evaluation in a systematic, evidenced, and traceable manner. The design process included decision making with respect to a number of L&T aspects such as L&T method and style, student assessment, feedback, and reflective practice.

Background to the case study. The Product Design Programme of Study at the University of Leeds accepted its first cohort of students in September 2003. The module design referred to in this study was part of 'PDES2140: Design Studio'. This is a Year 2 (Semesters 1 and 2) module managed by the School of Mechanical Engineering. It is a key module as it is worth 40 credits (a third of the Year 2 credits). The delivery of the module is structured around the completion of four product design projects. Each project focuses on different aspects of product design and it is worth 10 credits; as such each project is treated as a sub-module of PDES2140. The sub-module/project, referred to here, was entitled 'PDES2140–Value Engineering Project; it was the third out of the four projects and it was delivered in Semester 2.

The term 'Value Engineering' was used in its wider meaning and context for the purposes of that project. The rationale for such use was based on the following situation (text taken from the project introduction): 'The delivery of competitive products requires the design of products that add value in the eyes of interested parties. Traditionally, value-adding was based on the delivery of products at the lowest cost with the maximum number of product features. Over the last two decades it has been progressively acknowledged, in industry and academia, that value-adding is not cost-driven but lifestyle-driven. This implies that value-adding embraces a very complex blend of product characteristics that includes usefulness, usability, and desirability characteristics'. That is, focus was given not only to product functionality (e.g., carrying out a function/cost analysis through FAST[7] diagrams) but also to product branding and aesthetics; two other important factors in the design of consumer products.

The aim of the project was to allow students to experience the importance of Value Engineering practices in the design of a product and its contribution to a company's competitiveness. A number of tools and methods for value opportunity analysis were presented to the students but they were expected to identify others through literature search. Students were encouraged to use such tools and methods to define value attributes for their products through carrying out a value opportunity analysis. Such analysis focused on elaborating value opportunities associated with product functionality, product branding, and product aesthetics.

Consideration of the defined module learning outcomes [36], in conjunction with issues on the delivery of product Design Studio sessions [37], led to a decision to implement principles of the problem-based learning approach [24,38–43] for the purposes of the Value Engineering project. According to Saving-Baden [40] the rationale of problem-based learning is based on two assumptions. The first is that learning through problem situations is much more effective than memory-based learning for creating a usable body of knowledge. The second is that in many professions problem solving skills (e.g., medical or design skills) are more important for doing the job, than memorization of curriculum content.

The key characteristic of the problem-based learning approach adopted for the purposes of the module design was the fact that students, in small teams, were asked to explore a problem situation (e.g., definition of a company's brand). Through such an exploration, students were expected to examine the gaps in their own knowledge and skills in deciding what information they needed to acquire to resolve or manage the situation with which they were presented [40]. This approach was different from traditional practices in the delivery of product Design Studio sessions in that the focus was not on problem solving, whereby students were expected to answer a series of questions or resolve a problem from information supplied by a lecturer.

A number of L&T aids and materials were used to support the selected L&T approach and methods, and to enhance the achievement of the specified learning outcomes. Table 3 summarizes the L&T aids and materials used, the rationale for their use, a short description from their actual use, and their main contribution to the delivery of the module (project).

5.1.2 STRUCTURED EXPERIENCE

The analysis and evaluation of the module design process were informed by data gathered from the PGCLTHE mentor, the module manager, the staff associated with the delivery and assessment of the module, and the students. Reflection Space was used to support this analysis and evaluation. Tables 4–7 give examples on structuring and evidencing reflection

[7] FAST stands for Function Analysis Function System Technique; it consists part of a typical value engineering toolkit.

Table 3. L&T aids and materials used.

L&T aids and materials used	Rationale for their use	Short description of actual use	Main Contribution to:
Standard and extra handouts	Summarise Design Studio sessions and provide extra L&T support tools.	Available to the students during the Design Studio workshops/ seminars and the design clinics.	Fulfilment of Design Studio objectives.
Recorded BBC lecture (DVD player)	To highlight the importance of value engineering practices to the design of competitive products and to augment students' motivation.	Playback of the recorded lecture during a Design Studio session.	Fulfilment of Design Studio L&T objectives.
Project website	To enhance student accessibility to project information, throughout the execution of the project, by providing an up-to-date point of reference for the project.	Continuous update of the website content to reflect progress of the project (e.g. availability of links to project phases as appropriate).	L&T good practice.
PowerPoint	To enhance the delivery of concepts and methods associated with value engineering practices.	Progressive build up of theoretical concepts and practical demonstration of associated methods.	Fulfilment of Design Studio L&T objectives.
Laser pointer	Quick, precise, and long distance pointing.	Pointing on the projection screen while lecturing/tutoring away from the PC.	L&T good practice.

Table 4. Example of structuring and evidencing reflection on L&T approach through Reflection Space.

Reflection Perspective: Reflection on L&T approach	
Pair	**Reflective comments**
Opportunity: L&T approaches and styles	The implementation of principles of the problem-based learning approach proved successful because students were enabled to learn through doing rather than learn through being told. The tasks of preparing an initial product proposal, then updating this proposal while providing justifications for their updates, and producing a physical prototype of their proposed product proved central in enabling the students to directly discover the generation of knowledge, and to then test out the extent to which that knowledge works in practice. For example, during the second phase of the project, the problem situation given to the students provided them with additional information related to issues raised in the first phases of the project. The problem situation given required the students to decide what assumptions were needed, and why, what information was relevant and what steps they had to follow in order to solve the problem. To achieve this, the students had to use previously learned knowledge and build connections to previously learned concepts and materials presented to them during year 1 and year 2 of the programme. In other words, the group work tasks of the Value Engineering project aimed at fostering the ability of the students groups to synthesize what they have learned during the Design Studio elements of the course, and connect their new knowledge to the framework of understanding that they were developing on the significance of value opportunity analysis to the design of competitive products. As a result, the students had a multi-sensory experience that made them feel relieved of the necessity to take someone else's word for it. This indicated that the problem situations challenged the students to develop higher-order thinking skills, moving them beyond Bloom's [44] lower cognitive levels of knowledge and comprehension to the higher Bloom levels, where they analyze, synthesize, and evaluate. Therefore, an action that is derived from the aforementioned is to consolidate and enhance the implementation of principles of the problem-based learning approach.
Constraint: L&T context	The fact that the module was designed to include a range of intellectually challenging activities required the students to demonstrate initiative and undertake actions; however, some students felt uncomfortable with this way of working because they were not used to it. One way to improve this situation is to inform the students of the way of working that is required for the completion of this project at an early stage (i.e., during the introduction of the project). Another reason that some students felt uncomfortable was the fact that some teams consisted of three students. For example, the definition of the brand and the preparation of a company mini exhibition stand were both complex problems that required not only the commitment of all the team members but also the coordination of the work carried out in order to be completed in time. Johnson et al. [41] suggest that student accountability can be improved if the students are assigned to teams of four to five. Therefore, an action that is derived from the above is to enhance this situation by making sure that students groups have a minimum of four persons. Further, it was observed that the deadlines set for the assignments were tight. To this end, a further action is to incorporate more slack in the project schedule, to allow some extension of deadlines for students with good reasons for requesting them if needed.

Table 5. Example of structuring and evidencing reflection on L&T feedback through Reflection Space.

Reflection Perspective: Reflection on L&T feedback	
Pair	**Reflective comments**
Opportunity: Feedback methods	Feedback was provided by the PGCLTHE mentor, the module manager of PDES2140, the staff associated with the delivery and assessment of the Value Engineering project, and the students. Overall the feedback comments were positive. A number of opportunities and refinements for improving the project were identified as this was the first time that the Value Engineering project, and the PDES2140 module, were run. To this end, a derived action is to continue to collect systematic feedback comments from the students and associated staff.
Constraint: Meaningful involvement of students and teaching context	The methods used to collect feedback from the students were those of completion of two feedback forms (video lecture and overall project feedback) and of completion of two learner's reports. The students participated fully to the completion of the learner's reports and thus the feedback was comprehensive. The reason was that the learner's report was assessed and feedback for the module was collected in an implicit manner. In contrast to the learner's report, the participation of the students to the completion of the overall project feedback form was poor; only seven students responded out of the thirty-one. One reason for this might have been the fact that students were asked to complete the form in their convenience rather while being present at the Design Studio area. To this end, a derived action is to reconsider the timing and scheduling of asking the students to complete the overall project feedback form.

Table 6. Example of structuring and evidencing reflection on L&T technology through Reflection Space.

Reflection Perspective: Reflection on L&T technology	
Pair	**Reflective comments**
Opportunity: L&T aids and materials	The project was supported by effective learning and teaching materials. For example, the project website proved central to the completion of the project because it enhanced students' accessibility to project information, throughout the execution of the project, by providing an up-to-date point of reference of project related information. Another example is that of the recorded BBC lecture. This was shown to the students during the early stages of the project and aimed to accommodate the initial stages of surface learning by the students. This has been in accordance with Jenkins et al. [27] who suggest that as a general rule at least some surface learning is usually necessary early in a course to establish essential cognitive foundations. To this end, a derived action is to keep developing learning and teaching materials to support students' surface and deep learning.
Constraint: Resource-finite L&T (staff, time, and cost)	Several staff were involved in the delivery of the Value Engineering project. It was identified that more staff were required to support the students with the modeling of their digital models and their preparation for the production (through rapid prototyping) of the physical models. To this end, a derived action is to involve postgraduate students to support the students during their modelling activities.

Table 7. Example of structuring and evidencing reflection on L&T content through Reflection Space.

Reflection Perspective: Reflection on L&T content	
Pair	**Reflective comments**
Opportunity: Subject knowledge and authority	The project content was selected through consideration of the project (module) learning outcomes. The content related to real-world problem situations and offered tools, techniques, and methods to address them. The definition of the problem situations, as well as the selection of the tools, techniques, and methods, were informed by the Visiting Professors (industrial experience), senior academic staff (academic experience), and of the first author's teaching and research experience. Overall, the project content was selected in a way to prompt students to believe that the knowledge they gained would be useful beyond the demands of assessment. To this end, a derived action is to consolidate and enhance the project content through exploitation of the industrial and academic experience of colleagues.
Constraint: L&T needs of students	This was the first year that the Value Engineering project, and the PDES2140 module, were run. As a result, feedback from students and other sources was not available during the design of the project. In general, such feedback is necessary to validate the identified learning and teaching needs. Taking this into account, it was identified that there was a need to continuously monitor both the defined learning outcomes for this project and the feedback received by students. In this way, alignment between the learning and teaching needs of the students and the learning outcomes of the project can be assured. Furthermore, it was identified that there was a need to keep up to date with regulations and guidelines associated with equal opportunities, and health and safety, in order to secure an optimum learning and teaching experience for the students.

Table 8. Actions for improving future module design and review practice.

Reflection perspective	*Type of action* – Description of action
Reflection on L&T approach	*Consolidate and Enhance* – Implementation of principles of the problem-based learning approach.
	Change – Incorporate more slack in the project schedule to allow some extension of deadlines for students with good reasons for requesting them if needed.
Reflection on L&T feedback	*Consolidate* – Continue to collect systematic feedback comments from students (e.g., through learner's report) and associated staff.
	Extend – Reconsider the timing and scheduling of asking the students to complete module feedback forms.
Reflection on L&T technology	*Consolidate* – Development of L&T materials and aids (e.g., project website, recorded lectures) to support students' surface and deep learning.
	Extend – Involvement of postgraduate students to support students design activities.
Reflection on L&T content	*Consolidate and Enhance* – Development of module content through exploitation of the industrial and academic experience of colleagues.
	Consolidate – Ensure alignment between L&T needs of students and the module learning outcomes.
	Extend – Secure an optimum L&T experience for the students (e.g., keep up to date with regulations and guidelines associated with equal opportunities, and health and safety).

practice with reference to the module design process through the four L&T perspectives of Reflection Space.

Application of Reflection Space to the analysis and evaluation of the module process led to the identification of a number of actions for consolidating, extending, and enhancing existing module design or review practices in the context of continuous improvement. Table 8 lists the actions identified from such analysis and evaluation, and classifies them according to the type of the action to be taken. Actions are classified as consolidate, extend, change, enhance, and remove [2,45].

5.2 Discussion on the Application of Reflection Space

This section is associated with the inform relationship of the research methodology (shown as feedback arrow in Figure 1). The discussion below is based on evidence originating from the written feedback comments on the case studies as provided by the PGCLTHE tutors' (see footnote 5). Such evidence has been further augmented through anecdotal evidence originating from initial interactions and follow-up informal meetings with the PGCLTHE tutors on the potential of Reflection Space to improve current reflective practice.

Assessing reflection is known to be difficult [46]. The second author has looked to many assessed essays where students (i.e., teaching staff) were required to reflect on their practice. The best got 80%, the worst 30%. The best essay was indeed best – but at what? The content was better; the spelling, grammar, syntax, structure, and punctuation were better. But was the reflection better? Not nearly as much as the difference between 80 and 30%. When, however, this author came to assess the reflections of the first author on the use of the Reflection Space approach to his consolidation, extension, and enhancement of the module design and review practice, it was clear that the reflections produced through the use of this approach were much more realistic than those simply derived through essay writing. Application of Reflection Space not only demonstrated that key reflective perspectives of L&T have been considered but also demonstrably led to crisp action planning and forward thinking, based on systematic, evidenced, and traceable reflective analysis and evaluation.

The completed case studies have shown that Reflection Space can give the opportunity to teaching staff to capitalize on the Schon's framework [11,12] (i.e., reflection-in-action and reflection-on-action) by cross-fertilizing information obtained, or produced, during these two different types of reflection. For example, application of Reflection Space not only allowed documentation of information on the teaching style as gathered during the delivery of a lecture, or a workshop, but also gave directions on post-activity thoughts on how effective the adopted style was. These thoughts can set a basis upon which actions for improvement can be identified and planned. Furthermore, the studies have shown that although Reflection Space strongly relates to practical reflection (i.e., the second level of reflection according to Van Manen [19], see Section 3) it also relates to critical reflection (i.e., the third level of reflection). This is because it allows for incorporation of critical judgments on professional activity, such as judgments on alignment between L&T needs and application of equality, health, and safety regulations.

The studies have also shown that Reflection Space can significantly contribute to satisfaction of objectives of knowledge management practices, as identified by the work of Davenport et al. [10] (see Section 3). For example, Reflection Space can contribute to the creation of knowledge repositories (objective 1) in design education because: (a) as a method for systematic, evidenced, and traceable reflection practice, it can support the development and establishment of structured internal knowledge, and (b) as a means of

identification of 'lessons learned', it can support the documentation of informal internal knowledge. Furthermore, Reflection Space can contribute to an enhancement of the knowledge environment (objective 3) because it can support knowledge use and sharing through the derivation of actions for improvement that can be traced back to the originally made reflective comments.

6. Conclusions

This study discussed the value of reflection in enhancing knowledge management in higher education and aimed to support teaching staff in design education during their individual reflection practice by addressing the following questions: What do we mean by reflection? How can I reflect? How will I know when I've reflected well? How can I show that I've reflected successfully?

An action-research based methodology was used to carry out the reported research. The credibility and validity of the research findings are founded on characteristics of action research [6,7,47,48]. The research framework indicated that an efficient way of helping teaching staff both to reflect and to evidence their reflection can be to provide them with approaches or tools that can serve as devices to help them to focus and direct their thinking to those areas of their work where reflection can pay highest dividends. To this end, Reflection Space was introduced to present key learning and teaching (L&T) perspectives and to demonstrate how to bring them into a single plane of reference[8]. Although Reflection Space mainly relates to the reflection-on-action type of reflection as described by Schon [11,12], it can enable an integrated approach to reflection practice as it allows for the fertilization of information gathered during reflection-in-action practices.

The study emphasized the importance of systematic, evidenced, and traceable reflection practice to design education. It was highlighted through the detailed case study that establishment of effective reflection practice by both students and teaching staff is key in achieving and sustaining high levels of quality in design education. The study focused on aspects associated with the individual reflection practice of teaching staff. The case study dealt with an application of Reflection Space to the analysis and evaluation of a Design Studio module design process, and it illustrated the range of reflection that should, and can, be encouraged to teaching staff. It demonstrated that Reflection Space can be a powerful and practical L&T reflection approach for the purposes of design education in the context of enhancing knowledge management practices in higher education [23].

The widening agenda in education includes that of widening participation in higher education, where there are many more students from diverse cultures and educational backgrounds in the system than was formerly the case. This makes it all the more necessary to legitimate student reflection, and for teaching staff to have close encounters with the range of student reflection which can be uncovered, so as to enable them to tune in better to the 'widened' student community. Future research could explore the applicability of Reflection Space to group settings. According to Bridger [18], the study of group process always should be undertaken in the context of work. Thus, it could be of the interest of future research to explore group dynamics, through the double task concept, with regard to conducting, monitoring, and communicating collective 'Reflection Spaces'.

It is probably unwise to attempt to 'teach' people to reflect (whether they be students, professionals, or employees). The process of reflection can indeed be illustrated to those whose reflection is to be improved, but in the final analysis reflection remains an individual act in most circumstances (though the increased benefit of a group of people being involved in shared reflection is even more significant in many situations where collaborative and team activity is to be encouraged). In short, there has been no better time to get our act together regarding evidencing reflection – both our own reflection, and that of our students.

[8] It is acknowledged that teaching staff may find useful to expand, or detail, the L&T perspectives currently represented in Reflection Space. For example, an additional perspective could focus on formative and summative assessment, and could deal with opportunities and constraints associated with this perspective.

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