



2016

# A Different Type of Lighting Research: a Qualitative Methodology

Kevin Kelly

Dublin Institute of Technology, [kevin.kelly@dit.ie](mailto:kevin.kelly@dit.ie)

Follow this and additional works at: <http://arrow.dit.ie/engscheleart2>



Part of the [Electrical and Electronics Commons](#)

## Recommended Citation

Kelly, K. (2016). A Different Type of Lighting Research: a Qualitative Methodology. *Lighting Research and Technology*, July 29. doi: 10.1177/1477153516659901

This Article is brought to you for free and open access by the School of Electrical and Electronic Engineering at ARROW@DIT. It has been accepted for inclusion in Articles by an authorized administrator of ARROW@DIT. For more information, please contact [yvonne.desmond@dit.ie](mailto:yvonne.desmond@dit.ie), [arrow.admin@dit.ie](mailto:arrow.admin@dit.ie), [brian.widdis@dit.ie](mailto:brian.widdis@dit.ie).



This work is licensed under a [Creative Commons Attribution-NonCommercial-Share Alike 3.0 License](#)



# **A Different Type of Lighting Research – A Qualitative Methodology**

**Kevin Kelly BSc MSc EdD**

**College of Engineering & Built Environment, Dublin Institute of Technology, Ireland**

## **Abstract**

As lighting researchers we can learn from our colleagues in the humanities who have progressed Qualitative Research methods to a high level of rigour. We should consider using Qualitative Research Methods more. Such methods allow exploration of complex issues involving human behaviour and facilitate researchers to address difficult to answer questions that otherwise go unanswered. Good quality Qualitative Research can provide rich explanations of what went on in a given situation. Validity and Reliability are considered differently with this type of research methodology. This paper attempts to identify when qualitative research is appropriate, what questions it can answer in lighting research, how it is done, list the features and provide a simple brief example of a post occupancy evaluation case study. It is argued that qualitative research can be used with quantitative research; before quantitative research to inform it or afterwards to explain it; but it can also be extremely informative in itself and act as a catalyst for change to the reader who can see the outcomes in a context that applies to them. For example the reader can extrapolate insightful findings from a Case Study to their own applications more generally; in fact this is how the quality of such research is often evaluated.

Key words:

Research methods, Qualitative Research, Case Studies, research in lighting, triangulation.

## 1. Introduction

Lighting professionals often come from a scientific or engineering background that relies on good mathematical skills; and from this they inevitably devise solutions that use standard design and problem-solving skills. Research skills in engineering and lighting tend to be from the *Positivist* tradition; this is based on a *Realist Ontology* which is an objective reality. But there is also a *Relativist Ontology* that is subjective. Whichever is the case should determine the methodology to be used. This means, for example, that if what we are investigating are subjective views or behaviour then a *Qualitative Methodology* should be applied.

Good quality scientific based research is widely viewed by lighting professionals to be rigorous and objective driven, using empirical methods in experiment driven systemic methods that test hypotheses and justify conclusions. Such positivist traditions sometimes argue that such a truth can never be confirmed, only disconfirmed, i.e. the concept of falsifiability <sup>[1]</sup>. Of course there is also bad quality positivist research but this is quickly identified by experienced researchers and weeded out through peer reviewing. There is also bad quality *Qualitative Research*. This can appear in non-peer reviewed publications and can be based on unreflected data or anecdotal evidence or even plain prejudice or bias. This tends to create a negative view of the whole field leading to a widespread view in our profession that *Qualitative Research* is unverifiable and relies too much on the researcher and so is used by charlatans and frauds; and this does happen – no argument with that.

Traditional *Positivist Research* is deductive. It usually begins with a hypothesis or theory and a conclusion is drawn from assumptions underlying those theories. There is tight

control of the variables. It is based on logic and facts. If something is true for one then it is true for all (provided the premises are true).

Qualitative Research is inductive. It attempts to make broad generalisations from the specific case study. We explore the area, ask the questions, examine if there is a pattern and conclude with an observation; a theory that can be tested further if necessary. There is no absolute truth concluded but with good quality Qualitative Research there can be *buy in* from the reader who then applies the theory to their own situation. Qualitative Research can be used when we do not know exactly what it is that is happening. This is often the case when humans use our lighting or our controls systems for example. What do people think about the quality of the lighting; have they thought about it or reflected on it?

This paper strongly argues that good quality Qualitative Research can be used to explore complex human behaviour such as non-adoption of low energy technologies when we as professional only see benefits in reducing energy. How many times do we see users override a control system to the frustration of the design engineer who has designed it expertly for their needs? *If they would just leave it alone, things would be fine* - thinks the designer; who then goes off and applies the same unsuccessful design in countless other buildings. Qualitative research can be applied here to examine the problems. Why did this behaviour happen in this case? Can we change the design to improve human behaviour? Qualitative research allows the designer empathise better with the user and so improve the quality of work going forward.

It is not enough to gather just anecdotal evidence. It is required to get users to reflect on their behaviour. This sometimes requires that they are informed first. Great care is required

to gather reliable data without distorting the reaction of the subjects of the interview. They must not be patronised, bullied or led unduly. It is not the intention of the researcher to change behaviour or views but to find out what it is that is happening. The researcher must be trained and skilled.

This paper will describe one example of a Qualitative Research case study undertaken by an undergraduate student (<http://arrow.dit.ie/sdar/vol1/iss1/6/>). In such a Case Study the reader decides validity and whether the researcher was biased or if findings have application for them. The local narrative can then provide a theory that can inform widespread practice, possibly after further research.

When we want to know what someone thinks we must ask them. Often we design questionnaires to do this but sometimes we need to be more open to allowing the interviewees tell us what they really think about something or why they did something. Sometimes they will not know the answer to this themselves until they reflect on it. This can be a minefield and it is an anathema for positivist researchers who want to control the research parameters. Nonetheless there are times when this is necessary.

Therefore this paper questions the absence of qualitative research methods within lighting applications and argues that lighting professionals should understand that there are a variety of legitimate and rigorous research methodologies and methods covering the spectrum from the positivist quantitative approach to a more interpretative qualitative approach.

This is not a new debate. Petroski<sup>[2]</sup> refers to Snow's famous lecture in Cambridge in 1959 about the two distinct intellectual cultures of science and the humanities. Petroski<sup>[2]</sup> argues that Snow's lecture, and the sometimes vitriolic debate that followed, epitomised the gulf between the sciences and the humanities and concluded that positivist traditions have much to learn from the qualitative research methods used by our colleagues in the humanities. Indeed Berliner<sup>[3]</sup> wonders if the use of qualitative methods, such as those used in educational research, are the hardest science of all. He argues that qualitative research is often considered soft, unreliable and imprecise when compared with other sciences and engineering. Berliner<sup>[3]</sup> concludes that qualitative research is *the hard to do science*.

Qualitative Research is about the local rather than the general, and usually involves human actions and interactions. Such data is notoriously difficult to plan, collect, analyse, code and present (particularly to an audience who are more comfortable with quantitative data and studies with large sample sizes). In qualitative research the context is critical because of the myriad of interactions that occur in different applications and cultures.

There is also a myriad of qualitative research methodologies that can be employed, including phenomenology, phenomenography, ethnography, case study research and narrative research. This paper focuses on Case Study Qualitative Research. With good quality case study research, qualitative data may be presented in a rich format and set within a context that the reader is invited to judge and select appropriate data from, which may apply to their own situation. The findings must be presented with the underlying assumptions and limitations of the research made clear to the reader. Critical analysis of the methodology is particularly important in qualitative research. Studies should be presented in

sufficient detail and clarity to allow replication or at least offer opportunity to build systemically on their findings. Qualitative studies may finish by identifying future research questions that were not addressed in the study. The very nature of qualitative research is such that it often ends in surprises that the researcher may not have expected nor had time or resources to address.

Apart from not being able to answer questions with multiple constructions, one of the weaknesses of quantitative research is that it may result in what is described by social scientists as a thin description of what happened; whereas qualitative studies are usually rich and thick in data. For example, quantitative studies can show trends and correlations but they are very often unable to provide explanations or reasons. Qualitative studies allow theory to emerge from the data and hence the richness in explanation.

This paper will suggest when qualitative research is appropriate, how it is done, how adequacy of the research is assessed and provides an example from a lighting post occupancy evaluation study.

## **2. Engineering examples**

Qualitative methods have been shown to be successful for post occupancy evaluation of buildings, for example the Probe series in the CIBSE Journal some years ago is a good example where both quantitative data and qualitative data was used to evaluate the success or otherwise of innovative building design and its impact on building users. This was a series of post-occupancy case studies that began in 1994 and were undertaken by physicist Bill Bordass and behavioural scientist Adrian Leaman to create a building assessment procedure.<sup>[4]</sup> This research influenced building design and operation significantly.<sup>[5]</sup> It was

used to find out if building users were satisfied with comfort levels and the degree of control they had of energy use within buildings which were then being designed to use significantly less energy than previously. If energy usage of a building is higher than it should be, then qualitative methods can be used to investigate user behaviour, knowledge and attitude. A well designed building, services and controls will not function well from an energy perspective unless its operation and human behaviour in this regard is satisfactory and users are satisfied with the performance of the system. To achieve this fine balance between minimising energy and maintaining user satisfaction, it is acknowledged in many Chartered Institute of Building Services Engineers (CIBSE) publications that building occupants must be energy aware and have some level of control of services and comfort levels. To evaluate energy performance, utility bills and other quantitative data may be used. But if the energy performance of the building is higher than expected then human factors usually come into play and evidence of the knowledge, attitude and behaviour of building users may need to be examined thoroughly. This evidence will be qualitative. It is not just anecdotal, but instead it should be rigorously collected and analysed. There is a danger that due to a lack of knowledge (and hence respect), qualitative research can be perceived as simplistic. An engineer without adequate knowledge and skills in qualitative research may attempt to carry out the research through questionnaires or interviews; but without the rigour required, in both the acquisition and analysis, the findings are likely to lack validity and credibility.

Quantitative research may indicate a problem that cannot be explained and so needs further investigation through qualitative methods. Sometimes quantitative studies cannot be undertaken because the theory and hypothesis are unclear and so in that instance Qualitative Research is necessary beforehand. So it is important to note that qualitative and

quantitative methods are not mutually exclusive. They can be complementary to one another and the qualitative aspect can deepen explanation as well as provide answers to research questions. They can also be used to triangulate findings but Qualitative Research can also be informative on its own.

### **3. Qualitative Research**

It might be useful to present some material here in the form of questions which might arise from an audience of engineers. A hypothesis for this part of the paper could be that “Rigorous Qualitative Research can be Useful in Engineering”. From this, the following questions might be posed:

1. When is qualitative research appropriate?
2. How is qualitative research done well and how is qualitative data analysed?
3. How is adequacy of Qualitative Research assessed?
4. Can you list the features and provide an example of qualitative research in engineering?

#### **3.1 When is Qualitative Research appropriate?**

Qualitative research is often exploratory; it is useful when it is necessary to investigate peoples’ views or human behaviour or identify why something has happened or not happened in a building or elsewhere, or to find out how well or otherwise something performed but for which quantitative data does not offer a complete picture. Guba & Lincoln<sup>[6]</sup> argue that research methods must follow the research questions. They refer to realist questions as ones that can be answered by factual data and relativist questions that involve human behaviour. The latter require a different way of finding out about things

they argue<sup>[6]</sup>. If the research questions are about what people think or know or do, then qualitative methods often offer the best solution. A wealth of information and data can be gathered from knowledgeable people about just most anything; but in particular about their own behaviour. Sometimes people may not even be aware of their behaviour until they are asked about it and reflect on it. The data collected in such research is rich because the researcher and reader not only find out what they did or did not do - but WHY. It is this aspect that allows a designer or engineer re-think something from the perspective of the user and provide a more user friendly solution. The use of phenomenology in architecture to examine peoples' perceptions and experiences of a building is a common example from a related discipline. As previously indicated a post occupancy evaluation of a building is an example in engineering and an example from one such lighting controls study is provided later in this paper. Engineering design is very often informed by user requirements or by user specifications and qualitative research methods are employed to ascertain these prior to design and also to evaluate the product from the user's perspective post-production. In summary, the circumstances where qualitative research might be used to advantage are:

- Human reaction to quality aspects of lighting with a new scheme or case study where the changes are multiple. In other words where it is the generality of the lighting being considered first (before the detail that might be considered later with a quantitative study.)
- Investigation of human reaction to lighting controls
- Where a richer description of human behaviour is required (possibly following a quantitative study)
- To allow the researcher or designer empathise better with users so as to improve practice

### **3.2 How is Qualitative Research done well and how is qualitative data analysed?**

Carrying out qualitative research well is difficult and the analysis of qualitative data can be daunting. Data collected from interviews can be enormous in volume and the methods of analysis must be carefully considered. Various software and methods are available to help the researcher but the researcher needs to have a thorough understanding of the analysis method before collecting the data ( before writing the interview questions).

Otherwise the researcher will end up asking themselves where to start or worse still, finish with data that does not address the issues adequately or appropriately or is incomplete. For example, it is quite common with novice qualitative researchers, who seek to obtain experiential data (knowledge of the participants' experiences), to analyse the interview data only to realise they have only obtained opinions and descriptive data instead of reflective accounts. Interviews are difficult to do because people are not always honest or sometimes may not realise or be aware that they know something. In addition, the wording and the sequencing of the questions can alter the answers to the questions.

As Qualitative Research has been widely used in the social sciences for many years, rigorous research methods are well established. Further information can be found in the references used in this paper and the recommended reading at the end. Qualitative methods useful in post evaluation case studies include in-depth interviews, focus groups, small surveys, participant observation and document examination. Well performed interviews can result in thick descriptions that allow a deep examination of what has happened and most importantly why it happened..

Good quality qualitative research will gather and analyse such data to answer research questions in a transparent way that convinces the reader of its authenticity, trustworthiness and rigour<sup>[7]</sup>. Various ways are used in qualitative research to do this<sup>[8]</sup>. The researcher always provides details of their own background, why they undertook this research and who else is involved or is funding it. In other words the researchers state clearly where they sit before saying where they stand on the issue. This facilitates the reader to better judge authenticity and risk of bias. The researcher must be reflexive throughout. This involves continuous reflection on the research, the findings and on oneself. Is this what I expected? If so have I led it unfairly? If not am I now repositioning my thinking to properly understand reality? An open mind and empathy with research subjects and their view of the world is critical. This is all done openly in the commentary so that the reader can properly judge it.

Interviews are carefully prepared, recorded and transcribed. The interviewer should write a reflective log of what happened in the interview and how they think the interview went<sup>[9]</sup>. Because such data collection is not easy, using a reflective log allows inexperienced interviewers to benefit by evaluating their own performance. Researchers should always 'pilot' the interviews to ensure the appropriateness and suitability of the questions and sequencing. It is often only after the transcript is analysed that the effectiveness of the interview can be evaluated; the pilot study should also include an analysis. For example, when this writer began his first qualitative study, he asked double barrelled questions which confused interviewees and this yielded poor data. At other times he allowed interviewees speak for too long on topics that were not relevant to the research. Sometimes the questions were not precise enough or the interviewees elected to answer a different

question than the one asked. Sometimes interviewees were interrupted by him so as to clarify a point but this disturbed their train of thought. Therefore reflection on and critical evaluation of interviewer performance is important so as to ensure improved quality data as it progresses. It is best to record interviews and not try to record notes when you should be listening.

Ethical responsibility is required. Summaries of interviews should be submitted to the interviewees so that they get a chance to clarify matters, add afterthoughts or correct misrepresentations. In this way the data is carefully considered and does not just rely on a quick response at the interview. Interviewing is time consuming for the interviewee and more so the interviewer. A one hour interview will typically take four hours to transcribe and summarise for an experienced interviewer and much longer for an inexperienced one. Ethical approval is also necessary with anonymity for interviewees normally required. This means colourful or individual quotes, which might accidentally identify a source, must often be omitted. The basic ethical requirement is that no harm can be allowed to come to sources because of their contribution to your research<sup>[10]</sup>. The standards of propriety have been raised in this area in recent years and the idea that you can let the data speak for itself whilst allowing harm to somebody's reputation or cause embarrassment to them are gone. Sometimes issues such as criticism of a product or a designer can be overcome by allowing the designer respond to any criticism and allow them have their say; but this has to be carefully thought through. Consideration must also be given to where the data will be stored, who will have access and when will it be destroyed.

### 3.3 How is adequacy assessed?

The term reliability used in quantitative studies is replaced with the term adequacy in qualitative studies. Although this term is often seen as adding to the perception that qualitative research is not rigorous or complex (i.e., it is just adequate), it relates to the credibility and trustworthiness of the research. It simply reflects the context-specific nature of qualitative research and the realisation that different research methodologies can be used to answer different types of research questions. Reliability does not apply in qualitative studies because the findings of the research will depend on the context<sup>[11]</sup>. However, adequacy includes both the validity and the transferability of findings. The research design chosen (methodology, methods, and participants) must ensure that the research is valid, i.e., that the most appropriate design to answer the research questions posed is used. Transferability depends on context but the findings are presented in a way which allows the reader to judge and select which aspects are appropriate and have application in their own context and to what extent.

Qualitative studies are intended to inform readers about things they did not know or things they wanted to hear more evidence about or maybe had not even thought about. The description is rich enough and detailed enough for the knowledgeable reader to extract that which applies to their case and they can then explore this more fully for themselves. So the qualitative study might act as a stimulus to further research by the reader in some cases or as a catalyst to a change of view or behaviour.

As mentioned earlier, in qualitative research a researcher provides their own background to the reader and highlights any baggage they bring to the research. For example if a

study into lighting controls was funded or carried out by the company supplying controls then this needs to be stated. In this way the researcher is on guard to be extra vigilant in being objective and transparently fair, and the reader is facilitated to act as arbitrator or judge of this by knowing the researcher's background. In this way the reader more easily assesses validity and transferability.

### **3.4 Can you list the features and provide an interesting example of Qualitative Research in Engineering?**

#### **3.4.1 Features of good quality Qualitative Research:**

- It can address complex issues involving human behaviour;
- The particular methods chosen are aligned to the research questions in a more flexible manner than is possible with Quantitative Research.
- Research questions evolve and expand as the research progresses and subject views inform the process – these are often the surprises and the most insightful findings;
- It has a wide variety of approaches including surveys; structured or semi-structured interviews and Focus Groups. Data collection is slow and data analysis difficult.
- It can explore a problem where there is no theory or hypothesis and isolation of variables is impossible;
- It recognises diversity and different perspectives and respects them;
- It is empathetic in that the researcher tries to see things from the subjects perspective;
- The reflexivity of the researcher and the research is made clear;
- It concludes with a theory that has broad application, or a hypothesis for further testing.

- It can precede Quantitative Research to more clearly establish theory or a hypothesis, it can follow Quantitative Research to explain it or it can be triangulated with Quantitative Research to verify it. It can also be informative when used on its own.

Qualitative Research is not intended to be conclusive though. It is often iterative and not intended to be a final solution normally. In summary good quality qualitative research is likely to include the following:

- Good quality interviewing techniques such as not leading the interviewee but not letting them waffle either; asking clear questions and being flexible enough not to lose important data that was not expected
- Critical reflection of interview data and technique documented
- Appropriate coding and critical analysis of data
- Transparent conclusions and findings that the reader can view directly from the evidence presented so that they can determine trustworthiness, credibility and transferability to their own situations .

### **3.4.2 An Example**

A number of years ago the author began supervising a mature student who was undertaking a final thesis for an honours degree. The student initially intended to do a post occupancy evaluation case study into the performances of lighting control systems in two buildings <sup>[12]</sup>. One building had sophisticated lighting controls and an identical building had no controls. He had access to each building and intended to gather data about installation costs, lighting energy data for each building and so on. He then intended to compare the two sets of data, calculate the expected annual savings with controls, calculate the payback and estimate value in monetary terms, visual comfort and savings and carbon emissions. This seemed to suggest that a straightforward quantitative study would be most appropriate. However when

he returned to the buildings after some months on his course, disaster struck. The lighting controls on the building had been disconnected. The research had to take a different direction to investigate the reasons behind the disconnection. Starting again, new research questions were written that could only be answered by questioning the people involved in the decision to remove the controls<sup>[13]</sup>. So began a qualitative study that asked why the controls were disconnected.

The researcher carried out semi-structured interviews, described by Robson<sup>[14]</sup> as allowing flexibility for the researcher to probe and for the interviewee to explain. Facilities managers, general managers, lighting/controls designers, caretakers, and lighting control technical specialists were interviewed. Interviews were recorded. Qualitative research must be rigorous if it is to be convincing and qualitative data must be organised well. It often involves inductive reasoning in that the data is often analysed without pre-conditions or set theory. This can result in huge amounts of data without categories, and qualitative data analysis software such as *Nvivo* might be necessary to help organise the analysis. With a thesis where time and resources are limited, data may be gathered under general headings or under a conceptual framework or the researcher may use template analysis. In the case of Doyle<sup>[12]</sup> some theory was applied before data collection began. Data was then presented to the reader and analysed through a conceptual framework using established methods of template analysis that were identified in his literature review of other research in this area. These were then fully explained and justified in the context of his research. This conceptual framework ensured questions on problems identified in the literature review were fully examined.

The problems identified in this case study included:

- Lack of coordination

- Inadequate user instructions  
(Including training, documentation & labelling)
- Wrong specification (controller type)
- User behaviour
- Wrong location of controller
- Poor commissioning

There were also other findings outside of the conceptual framework which were very insightful. One included the high cost of ongoing maintenance and the support required for the control system that had not been envisaged.

Template analysis<sup>[15]</sup> allows data to be collected in categories within a conceptual framework. But it must be emphasised that data analysis is not selective except in so far as gathering data under the headings established. Data yielded that is outside the conceptual framework can be also be categorised using template analysis after the data is collected. More theory then emerges from the data and has to be considered outside the original framework envisaged. For example in this case, the reasons why the controls were disconnected that were not known or expected when this research began. Nonetheless the bulk of his data was collected within the original conceptual framework identified from the literature review and the extra data was then small in volume and more easily dealt with. In his study Doyle<sup>[12]</sup> found that there was a major mismatch between what the designer thought was happening and what actually happened afterwards. A designer was interviewed in the research and explained that the fee structure was such that his job ended long before the building was occupied.

#### **4. Discussion**

It is argued in this paper that qualitative research may be an appropriate way to address certain types of lighting research. Hence lighting research should be expanded beyond its current positivist paradigm. Lighting researchers can learn a lot about qualitative research methodologies and methods from our colleagues in the social sciences who have been using such methods for many years. Engineering programs should educate students about the variety of approaches and research methods as well as the implications of using particular methods so that they are better able to make informed decisions when undertaking research.

So what can we learn from qualitative case studies? The answer is simple - everything we possibly can. Qualitative studies are open, exploratory and rich in data and description. They are often a stimulus for further investigation highlighting research questions for quantitative analysis, or as a follow on to quantitative studies which do not reveal the why of human behaviour or to triangulate with quantitative studies. But qualitative research can be extremely informative in itself and act as a catalyst for change to the reader who can see the outcomes in a context that applies to them.

Qualitative research is contextual and often involves complex human action and interactions. Data is often very difficult to make sense of and analyse. Analytical tools are necessary to grind through voluminous data. Analytical software may be necessary for larger studies, but for smaller studies a conceptual framework may be used when collecting data and then as an analytical tool at the later stages. This makes data analysis simpler. Template analysis<sup>[15]</sup> is also a useful tool for analysis of large amounts of qualitative data. But with qualitative research there is often surprises and unexpected data and methods of analysis must be flexible enough to deal with these.

The concept of adequacy is thought of differently in Qualitative Research than in Quantitative Research. Validity is about credibility and is judged by the readers. The findings either seem transferable for them or not. Usually with good quality studies they are partly transferable to a lot of other cases allowing the reader modify what they do in their own particular situation.

Rigorous qualitative research is time consuming and difficult to do but it offers a thorough and credible way of finding out about human behaviour in engineering applications. For further reading see an Introduction to Qualitative Research by Fisk<sup>[26]</sup>.

### **Acknowledgements**

This paper is partially derived from a conference paper originally presented at the ASEE conference in Vancouver in 2011 by the author and his colleague Brian Bowe of DIT<sup>[16]</sup>.

The undergraduate thesis referred to was published in shortened version in the SDAR Journal<sup>[10]</sup> and was undertaken by Bernard Doyle and supervised by the author. It is available online free at: <http://arrow.dit.ie/sdar/vol1/iss1/6/>

## References

- [1] Borrego, M. Douglas, P.E. & Amelink, C.T. Quantitative, Qualitative and Mixed Research Methods in Engineering Education. ASEE Journal of Engineering Education, January 2009
- [2] Petroski, H (2009) *Polarizing Cultures*; ASEE Prism Oct 2009 p25, ASEE.
- [3] Berliner, D (2002) *Educational Research: The Hardest Science of All*; Educational Researcher, Volume 31, No 8, pp 18-20.
- [4] CIBSE Journal and CIBSE Knowledge Portal: Probe series  
<http://www.cibse.org/knowledge-search?searchtext=Probe%20series>
- [5] Probe 19: designer Feedback. CIBSE Knowledge Portal:  
[http://www.cibse.org/knowledge/probe/probe-19-designer-feedback-\(1999\)](http://www.cibse.org/knowledge/probe/probe-19-designer-feedback-(1999))
- [6] Guba, E. & Lincoln, Y. (1998) *Fourth Generation Evaluation*. Calif: Sage.
- [7] Cohen, L. Mannion, L. & Morrison, K. (2000) *Research Methods in Education*, 5<sup>th</sup> ed. London & N.Y.: Routledge Falmer.
- [8] Denzin, N. & Lincoln, Y. (1994) *Handbook of Qualitative Inquiry*. UK; Sage.
- [9] Schon, D. (1995) *The Reflective Practitioner: How Professionals Think in Action*. New York; Basic Books.
- [10] Creswell, J. (1994) *Research Design: Qualitative and Quantitative approaches*. Calif: Sage.
- [11] Silverman, D. (2005) *Doing Qualitative Research, 2<sup>nd</sup> Edition: A Practical Handbook*. London : Sage.
- [12] Doyle, B. (2011) An Investigation into Why Lighting Controls Fail in Buildings, SDAR Journal issue 1, pp 33-40. <http://arrow.dit.ie/sdar/vol1/iss1/6/>
- [13] Denzin, N. & Lincoln, Y. (2003) *Collecting and Interpreting Qualitative Materials*. UK; Sage.
- [12] Robson, C. (2002) *Real World Research 2<sup>nd</sup> ed*. Oxford: Blackwell Science.
- [14] King, N.(Template Analysis) in Symon, G. & Cassell, C. (1998) *Qualitative Methods & Analysis in Organisational Research*. London: Sage.
- [15] Kelly, K & Bowe, B.(2011) Qualitative Research in Engineering Education; ASEE Conference Vancouver.

[17] Kelly, K. (2010) A Doctoral Thesis Examining Change in a HEI in Ireland: Changing Universities and the Response of Academics to Change in the Dublin Institute of Technology in Ireland. Lambert Academic Publishing; Germany.  
[http://www.amazon.co.uk/Doctoral-Thesis-Examining-Change-Ireland/dp/3838376714/ref=sr\\_1\\_4?ie=UTF8&qid=1326384921&sr=8-4](http://www.amazon.co.uk/Doctoral-Thesis-Examining-Change-Ireland/dp/3838376714/ref=sr_1_4?ie=UTF8&qid=1326384921&sr=8-4)

[18] Kelly, K (2009) Universities Changing in Response to a Volatile Environment. Book part-chapter for SEFI in association with Helsinki University.  
<http://arrow.dit.ie/engschelebk/1/>

Also available here:

<http://arrow.dit.ie/cgi/viewcontent.cgi?article=1006&context=engschelebk>

[19] Kelly, K (2009). *Implementing Change in Universities in Europe; A Case Study from Ireland*. ASEE conference in Austin, Texas USA

[20] Kelly, K. (2007) *Changing Universities*. In Conference Proceedings of SEFI 5<sup>th</sup> European Forum. Lapland, Finland. <http://www.ntnu.no/videre/sefi/pdf/KevinKelly.pdf>

[21] Kelly, K. & Murphy, M. (2007) *Academic Change in Higher Education in Europe*. ASEE conference USA.. <http://papers.asee.org/conferences/paper-view.cfm?id=5597>

[22] Kelly, K. & Murphy, M. (2007) *Academic Change in Higher Education in Europe*. ASEE Colloquium in Istanbul, Turkey.

[23] Kelly, K. (2006) *Academic Change in Higher Education*; Conference Presentation delivered at *SEFI Conference, Trondheim, Norway November 2006*.

[24] Kelly & Brennan (2015) the Evolution of a New Technological University in Terms of Policy Definition and Control of Implementation. Presented at HEIT conference Dublin Castle 2015.

[25] Kelly, K (2009) *Changing Academic Roles in Engineering Education*. IGIP Symposium; Graz, Austria.

[26] Flick, W (2009) *An Introduction to Qualitative Research*; Sage Publications; London.