Chapter 94
Engineering Design as Research

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ABSTRACT

Research is defined as an activity that creates new knowledge. This is often misunderstood in the engineering community as necessarily requiring a scientific contribution that advances the theory of some matter related to engineering materials or processes. Consequently, typical engineering research projects investigate physical phenomena thought likely to be interesting in potential applications or to describe the characteristics of processes used in engineering work. The results of such projects provide a fragmented, abstracted view of the phenomena investigated, which is difficult to use in engineering decision making related to contextualised situations. This chapter shows how the actual design of engineered artefacts is research because it provides knowledge of the impact of the integration of various elements of existing knowledge, which demonstrates the properties of the designs achieved through the design work and leads to discovery of solutions to the various challenges of integration discovered through the project which attempts to achieve the integration.

INTRODUCTION

Research is defined as an activity which develops new knowledge (Department of Education Training and Youth Affairs, 2001). A major challenge we have in understanding the nature of research is our preconceptions concerning the nature of knowledge, since the creation of knowledge is the objective of all research activities. In this chapter we introduce the particularly important issue of engineering activity and the act of design itself as research, that is, as methods of creating new knowledge. This is distinct from performing investigations about the engineering and design processes as an observer of those processes with the purpose of better understanding the processes. The idea of engineering activity and design being a research methodology requires explanation because it is quite different to the usual interpretation of research in engineering.

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It is usually expected that the knowledge that is developed in processes to which we assign the name 'research' is objective and generalizable to a wide range of problems. This understanding is derived from the idea of research as implemented in the natural sciences and fields inspired by their methods, in which the goal is to find out knowledge about the phenomenon or situation which is the subject of the work, and the work is regarded as completed when a sufficiently good theory or explanation of the situation is determined.

The idea of research concerning the discovery of generalizable knowledge about the subject matter of the investigation is prevalent in engineering related research conducted in universities, by both faculty and graduate students, and in the regulations for research degrees in engineering and in the engineering research journals published in recent decades. The engineering research journals of the 1950's, particularly prior to the changes in the US education and research system that followed Sputnik, reflected a different vision of the nature of engineering research and its relation to the achievement of engineering design. The latter will be discussed later in this chapter.

The idea of generalizability of knowledge relates to the manner in which it can be applied to situations other than the narrow set of situations in which the observations were made (Lee & Baskerville, 2003). Generalizability can be established in several ways and can have different meanings dependant on the manner in which it is achieved. The natural sciences use statistical analysis of observations to determine the confidence that can be established that the null hypothesis is not wrongly rejected, and so seek to establish results as being universally applicable across all analogous cases. Fields which accept interpretivist views of knowledge may be satisfied with developing knowledge that is true within the bounds of the situation of observation, without demanding that the knowledge obtained be demonstrated for a broader range of situations (Lee & Baskerville, 2003). In general, the notion of generalizability demands the assumption that the matter of observation is uniform across the range of the generalization so that the observed sample represents a wider space (Lee & Baskerville, 2003).

When we look for objective, generalisable knowledge about subject matter we narrow our view of the nature of knowledge through the Positivist lens to concerning knowledge about external things. This is not the only view of knowledge which exists, and unnecessarily constrains research since it excludes the development of knowledge of other kinds.

KNOWLEDGE

We present now a discussion of the nature of knowledge which is necessary to develop a top-down approach to the evaluation of methods of research. We review some recent distinctions in the description of knowledge.

"Know that" is a formulation used to describe declarative knowledge, following Gilbert Ryle's distinction between "knowing that" and "knowing how" (Ryle, 1948). This distinction has been noted as significant in engineering, where both kinds of knowledge are required (Bucciarelli, 2003). Declarative knowledge is a kind that can be articulated in words or mathematics that represent ideas concerning the nature and relations of things. As such, declarative knowledge is a form of knowledge which it is fairly easy to teach and learn because it is possible to reduce the teaching or learning to recitation of the representation of the knowledge. The recitative character of declarative knowledge is discussed by Biggs (Biggs, 1999). Declarative knowledge is any knowledge which can be formulated in statements which convey the knowledge itself, whether that knowledge is generalizable across a wide range of cases or of limited applicability.

"Know how" is Ryle's formulation to describe the capacity to perform a function. This capac-