A PROBLEM SOLVING APPROACH TO IDENTIFYING CIVIL ENGINEERING INFRASTRUCTURE PROJECTS

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Civil engineering infrastructure projects are solutions to problems facing communities, societies or even an entire nation. Addressing societal needs and problems is a key element of infrastructure project success. However, recent evidence suggests that decision makers often invest in projects that do not address clearly defined problems. Therefore, this research aims to contribute towards improving the identification process of civil engineering infrastructure projects. A desk study involving mapping of a generic infrastructure project life cycle onto two problem solving process models was undertaken. It was found that if civil engineering infrastructure projects are viewed as solutions to problems, ideas of a problem solving process can be adapted and incorporated into the identification process of infrastructure projects. This led to the design of a novel two-stage identification process for civil engineering infrastructure projects. The process brings together developers and concerned stakeholders to: first agree on the problem to be addressed, and second generate solutions, assess them and then choose a preferred solution to be implemented. Identifying civil engineering infrastructure projects in this manner ensures that public funds are spent on projects that address societal problems, provide the greatest benefits to society, and that they are spent in the most efficient way.

Keywords: civil engineering infrastructure, project identification, problem solving

INTRODUCTION

Civil engineering infrastructure projects, such as highways, bridges, airports and railways, form the backbone of any modern, successful and competitive economy (HM Treasury 2013). They promote prosperity and growth, improve quality of life and enhance the well-being of a modern society. The adequacy of infrastructure helps determine one country's success and another's failure. Good infrastructure raises productivity and lowers production costs, but has to expand fast enough to accommodate growth (World Bank 1994). Well-developed infrastructure is a critical factor for ensuring the effective functioning of the economy, as it determines the location of economic activities that can develop within a country, and integrates the national market as well as connecting it to markets in other countries and regions (World Economic Forum 2013). Therefore, client organisations for civil engineering infrastructure projects (often governments/public sector organisations) seek to ensure

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they invest in the right project at the right time in order to secure economic competitiveness in the long term (Gardiner 2005).

Although infrastructure developers strive to invest in the right infrastructure, evidence from McKinsey Global Institute (Dobbs *et al.*, 2013) suggests that decision makers often invest in projects that do not address clearly defined problems and improving project identification process could save $200 billion a year globally (ibid). The present paper is therefore important because it contributes towards improving the identification process of civil engineering infrastructure projects, and hence contributes to achieving this global annual savings. To begin, the importance of accurate project identification is discussed, and evidence for inaccurate project identification is presented. After this, the research problem and the approach to address it are outlined. Findings are then highlighted and discussed.

PROJECT IDENTIFICATION

Project identification is the process of identifying projects. The identification phase, according to Corrie (1991), comprises the preliminary appraisal of a potential project, and aims to decide whether a feasibility study should be undertaken. The outcomes of the identification phase include a list of options to be considered and the ground rules for the feasibility stage. The authors observe that the identification phase is often embedded in the concept phase, for example, Turner (2007), Association for Project Management (2006), British Standards Institution (2000), Abdul-Kadir and Price (1995) and Adams and Barndt (1988). The concept phase is the first phase in the project life cycle during which the need, opportunity or problem is confirmed, the overall feasibility of the project is considered and a preferred solution identified (Association for Project Management 2006). The tasks that must be accomplished during this phase often include: identifying need, establishing feasibility, identifying alternatives, preparing proposal, developing basic budget and schedule and identifying project team (Adams and Barndt 1988).

In addition, project identification appears to be insufficiently established in the internationally recognised project management standards and methods. For instance, the BS 6079 assumes that a project brief is prepared to trigger the project. It supposes that a preparatory work to prepare a project brief is carried out before the formal start of the project (British Standards Institution 2010). However, BS 6079 does not offer much advice on the process through which the project brief is produced. Moreover, PRINCE2 assumes a project mandate exists to trigger the project (Office of Government Commerce 2009). Although the project mandate is a “product”, PRINCE2 gives little information on the process through which this product is produced. Furthermore, The Royal Institute of British Architects (RIBA) Plan of Work assumes that the project is strategically appraised and defined before a detailed brief is created (Royal Institute of British Architects 2013). However, the Plan of Work offers no advice on the process through which the client’s strategic definition is produced. Here, the authors acknowledge the major strength of these project management standards and methods, and understand that they are project orientated. However, focus on these standards and methods has dominated project management practice and attention has to be given to the documents that trigger a project. The present paper is a step in this direction.

Although project identification is often not recognised as a discrete phase, previous research on critical success factors (CSFs) for infrastructure projects have indicated the importance of the project identification process. In fact, appropriate project identification is a critical factor for the success of Build–Operate–Transfer (BOT) projects, as it enhances the possibility of good outcome in the preliminary evaluation phase of a BOT project (Qiao *et al*., 2001). Tiong (1996), who studied the CSFs in winning BOT concessions, states that one of the crucial factors in winning a BOT contract is to identify and choose the right project to initiate. Building on documented experiences and lessons learned from successful BOT projects, interviews of BOT project promoters and government officials and their consultants and questionnaire surveys, Tiong's findings show that the ability to predict accurately the need for the project is the most critical task when identifying projects (ibid). Another research study into improving the delivery of social development objectives by modifying the way in which infrastructure projects are procured (Hawkins *et al*., 2006) concludes that the biggest potential social impact probably lies in the choice of the project, and the decisions taken in the early stages of a project (during the project identification phase) have the greatest impact on the achievement of social development objectives.

The foregoing paragraphs suggest that particular attention needs to be given to the important identification process of infrastructure needs/projects. This is particularly vital to the UK government, because ninety-five per cent of government policies is delivered through major infrastructure projects (National Audit Office 2013a). Therefore, accurate identification of infrastructure needs is essential to the government delivering its promises and objectives. This is supported by the fact that inaccurate identification of the need for infrastructure topped the UK's National Audit Office's list of key risks to value for money (National Audit Office 2013b).

The problem being addressed here is that although the importance of accurate identification of infrastructure needs is recognised, evidence from McKinsey Global Institute (Dobbs *et al*., 2013) suggests that decision makers often invest in projects that do not address clearly defined problems. Another evidence from the UK (National Audit Office 2013a) suggests that the UK government often commits to a 'solution' without fully understanding the context and exploring alternative options to determine which solution matches the real problem. According to Dobbs *et al*., (2013) this is because decision makers often default to investments in additional physical capacity without sufficiently focusing on the underlying needs and finding the most effective solutions to address that need.

The authors acknowledge that new civil engineering infrastructure projects are often the means for governments to deliver their policies and thus achieve political gains. This makes these projects political. However, it should be indicated that the present paper does not intend to explain why investment often flows into politically preferred projects. In the authors' view, the evidence presented above suggests that there is a need for an overarching identification process that allows the start point of every infrastructure initiative to be problem identification. Therefore, the aim of the paper is to contribute to the improvement of the identification process of civil engineering infrastructure projects in the UK, so that investment flows into projects that address societal problems. The following section explains the method used to achieve this aim.

METHOD

A desk study involving a review of two problem solving process models, and a comparison of the steps in these models with the project phases in a generic civil engineering infrastructure project life cycle was undertaken. The purpose was to show that if civil engineering infrastructure projects are viewed as solutions to problems, the project life cycle can be mapped onto a problem solving process. Ideas in these models were then adapted and incorporated into the identification process of civil engineering infrastructure projects.

The generic project life cycle used in the present paper was derived from comparing and contrasting several project life cycle methodologies (Institution of Civil Engineers 2009; Association for Project Management 2006; Young 2006; Chapman and Ward 2003; Abdul-Kadir and Price 1995; Adams and Barndt 1988). It comprises five generic phases: identification; planning; construction; operation and termination. The two problem solving models on which the generic project life cycle was plotted are best discussed in Proctor (2010) and Bransford and Stein (1993), though the following paragraphs outline the steps followed in each model and explain them briefly.

Bransford and Stein (1993) proposed a model for problem solving in which components are represented by the acronym IDEAL, where:

I = Identify problems;

D = Define goals;

E = Exploring possible options;

A = Anticipate and Act; and

L = Look and Learn.

According to Bransford and Stein (1993), problem identification is one of the most important steps in the problem solving process. Bransford and Stein argue that it is just as important to actively look for potential problems as simply to respond to them when they become critical or noticed (ibid). Defining goals often reflects how different people perceive the same problem. Therefore, defining the goals is a crucial step in moving towards a solution. Moving straight to the exploration of possible options without considering alternative goals often leads to difficulties in deciding which option to choose. Moreover, if goals have not been specified, generated options may not provide acceptable answers to a given problem. Exploring possible options involves reanalysing goals and considering alternatives that might be implemented to achieve those goals. Following the selection of an option, contingency plans should be made and the chosen option implemented. The last component of the IDEAL model is to look back at the effects of the implemented option and learn from the experience.

Proctor (2010) proposed a creative problem solving process based on the IDEAL model consisting of six stages as follows: define the problem area; gather information; define the problem correctly; generate solutions to the problem; evaluate and choose between possible solutions; and implement chosen idea correctly. According to Proctor, each stage involves activities that require first divergent thinking and then convergent thinking (ibid). In divergent thinking the task is to generate as many ideas and solutions as possible. Once an exhaustive number of ideas have been reached, convergent thinking takes place. The aim of this thinking is to focus on obtaining solutions to the problem based on the ideas from the divergent thinking.

In support of our argument, we have plotted the generic project life cycle to the two problem solving models, as illustrated in Figure 1. The purpose of this diagram is to show that if civil engineering infrastructure projects are viewed as solutions to problems, the project life cycle can be mapped onto problem solving process. Interestingly, the first three steps of the IDEAL model and the first five steps of

Proctor's model map on the project identification phase. Therefore, we adapt ideas in these steps and then incorporate them into the identification process of civil engineering infrastructure projects. The findings resulted from implementing this method are outlined and discussed in greater details in the subsequent section.

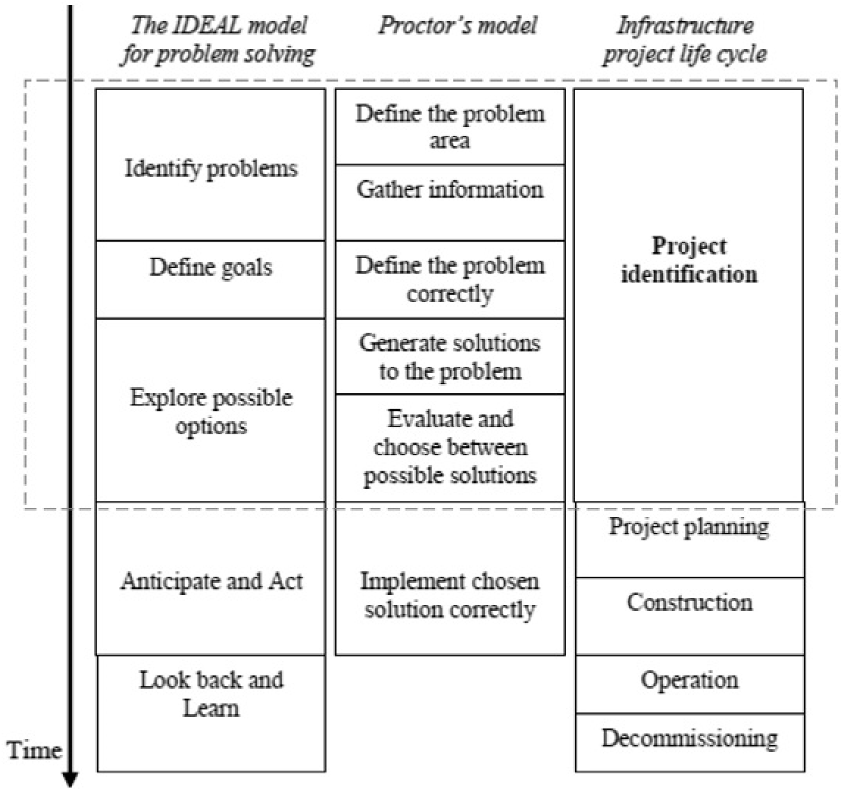

Figure 1 Civil engineering infrastructure project life cycle vs. problem solving process

FINDINGS AND DISCUSSION

Implementing the method explained in the foregoing section resulted in a two-stage identification process for civil engineering infrastructure projects, Figure 2. The proposed identification process allows civil engineering infrastructure projects to begin with problem identification. It brings together infrastructure developers and concerned stakeholders at a sufficiently early stage to: first agree upon the problem(s) to be addressed, and second to generate solutions, assess them and then agree on a preferred solution to be implemented.

The two-stage identification process involves activities that require first divergent thinking and then convergent thinking. Divergent thinking is the thinking that moves away in diverging directions so as to involve a variety of aspects and which sometimes lead to novel ideas and solutions. In contrast, convergent thinking is the thinking that brings together information focussed on solving a problem. In the divergent thinking, the task is to generate as many ideas as possible. There should be no limits to the ideas formed during this thinking. Once a satisfactory level of ideas has been reached, convergent thinking must be used. The purpose of the convergent thinking is to focus on obtaining solutions to the problem based on the ideas from the divergent thinking. The following sub-sections discuss the components of the proposed two-stage identification process in more details.

Stage 1: Agree on a problem

The product of Stage 1 is a well-defined, agreed upon problem. This stage involves five steps as discussed below.

Identify affected stakeholders
During this step infrastructure developers need to effectively identify all concerned stakeholders using a variety of stakeholder identification techniques. Stakeholder identification should be carried out constantly throughout the process. This is important because according to Warner (1984), problems and their corresponding solutions can be defined only within the context of the communities in which they exist. Therefore, it is crucial to identify the communities and the people who live in them before any attempts at generating solutions are made.

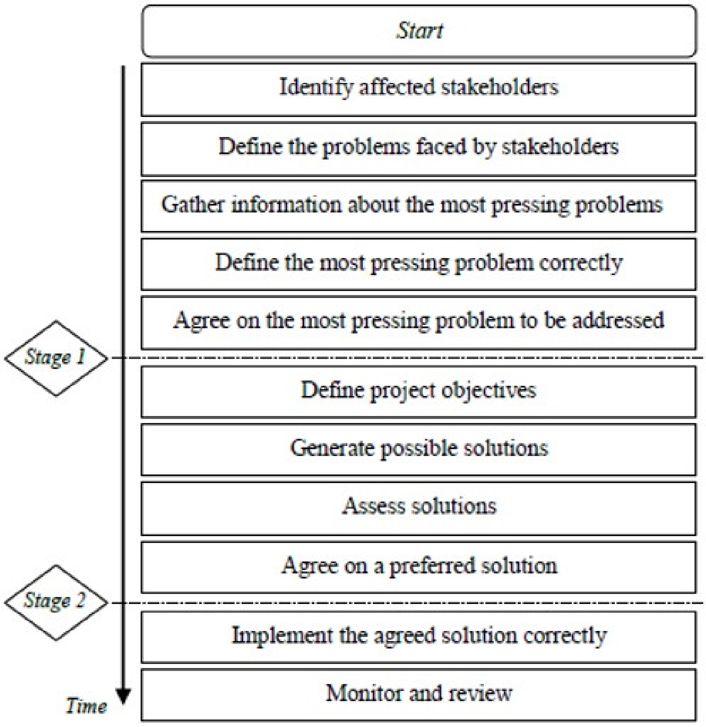

Figure 2 Proposed two-stage identification process for civil engineering infrastructure projects

Define the problems faced by stakeholders
Establishing and defining the problem to be addressed is probably the most important step in Stage 1 of the two-stage identification process, for unless the problem is already correctly defined it is unlikely that an effective solution can be found. Defining the problems involves divergent thinking to generate a list of problems encountered by the stakeholders. These problems are then assessed to a level that enables developers and stakeholders to prioritise them. Thus, ownership, priority and urgency of the problems should also be identified at this stage. Once the problems have been assessed, the most pressing problem can be identified and the next step (gather information about the most pressing problem) begins.

Gather information about the most pressing problem
This step can be considered as a fact finding mission. Developers and concerned stakeholders collect relevant information about the most pressing problem in order to increase the overall comprehension of the problem. As a result, new ideas will be

generated and the previously identified problem may now be seen from a new perspective. This requires the move to the next step of the process in order to define the most pressing problem correctly.

Define the most pressing problem correctly
This step considers a variety of problem perspectives. At this stage, developers and concerned stakeholders examine the information obtained during the previous step to generate possible problem redefinitions. Here, it should be indicated that since different stakeholders may have different perspectives of the most pressing problem, and hence different views to its precise nature, there is a need to consult all concerned stakeholder before the most pressing problem is finally fully specified. The objective of this step is a precise definition of the most pressing problem.

Agree on the most pressing problem to be solved
It is likely that the number of stakeholders in a civil engineering infrastructure project can be large, and involving all of them in agreeing on the problem to be solved can be challenging. Therefore, we introduce this stage gate – agree on the problem. Once the most pressing problem has been precisely defined and communicated to all concerned stakeholders, consensus must be sought. In order to facilitate this, infrastructure developers will need to work closely and collaboratively with concerned stakeholders in a spirit of openness and transparency throughout the whole process. Although specifying a consensus building mechanism is outside the scope of this paper, voting can be considered whenever a consensus on the problem cannot be built. However, it should be stated that what is more important than building toward a consensus on a problem is defining the problem correctly. Once the most pressing problem to be addressed has been precisely defined and agreed upon by stakeholders, Stage 2 of the two-stage identification process begins.

Stage 2: Agree on a solution

The product of Stage 2 is a workable, agreed upon solution. This stage involves four steps as described below.

Define project objectives
The first task to be carried out (once the most pressing problem has been well-defined and agreed upon) is to carefully define the project objectives in the problem situation. Defining objectives is a crucial step in moving towards a solution to a problem because if objectives have not been specified, solutions generated may not provide acceptable answers to the problem. Here, the authors recommend that alternative objectives should also be considered before moving to the exploration of possible solutions, because solutions may well be generated which solve a given problem, but deciding which solution to choose then becomes a difficult problem.

Generate possible solutions
This involves ideas finding to help structure the search for potential solutions. This step uses mainly divergent activity to generate many ideas using a variety of idea-generation aids. The aim is to explore alternative approaches to solving the problem. It should be noted that this may involve reanalysing the objectives (defined during the previous step) and considering options that might be employed to achieve those objectives. Once a number of possible solutions/options have been identified, the developers and concerned stakeholders are ready to move to the next step.

Assess and choose between possible solutions
In this step developers and concerned stakeholders choose the idea that can be transformed into a workable solution. It should be noted that the process of choosing a solution is likely to have a set of alternatives and also a set of assessment criteria. Therefore, assessing a list of alternative solutions involves measuring, trading-off or even scoring alternatives in terms of the assessment specified criteria.

Agree on a preferred solution
Once all possible, viable solutions have been assessed by the developers and concerned stakeholders, a preferred solution can be chosen and agreed upon. Communication with concerned stakeholders is significantly important in reaching agreement on the preferred solution. This requires developers and concerned stakeholders to work closely and collaboratively in a spirit of openness and transparency. It should be indicated that although specifying a consensus building mechanism is outside the scope of this research, voting can be considered whenever a consensus on a solution cannot be built.

In the two-stage identification process, infrastructure developers would work closely and collaboratively in a spirit of openness and transparency with other concerned stakeholders who have relevant knowledge and a stake in the infrastructure need/issue that is being tackled. This would enhance the understanding of the needs/problems where various stakeholders with different knowledge, stakes and values are involved. Bringing together infrastructure developers and concerned stakeholders to work cooperatively would also increase the likelihood that the nature of the problem can be better understood. Moreover, collaboration, openness and transparency increase the likelihood that solutions to problems faced by stakeholders can be found and agreed upon, because greater cooperation improves the prospect that diverse stakeholders may reach an understanding about what actions to take to address the problem.

Moreover, the divergent thinking involved in the process when identifying problems and generating ideas/solutions allows greater room to discover alternative means of solving problems. Thus, any problem to be addressed will be a legitimate problem, and any chosen solution to address it will be the most appropriate and will not become subject to controversy at later stages of the project life cycle. In addition, using a problem solving process as a means of developing and delivering civil engineering infrastructure projects paves the way for the start point of every infrastructure initiative to be a problem identification.

The authors acknowledge that some problems may not be definitively described. These problems have been called “wicked problems” – those that are complex, unpredictable, ill-formulated or intractable, and any proposed solution to address them often turns out to be worse than the symptoms (Rittel and Webber 1973; Churchman 1967). However, the proposed two-stage identification process helps facilitate a more understanding of the seriousness of these problems and puts forward possible responses to them through collaborative working, divergent and convergent thinking, openness and transparency. These strategies for dealing with wicked problems have been proposed by (Head and Alford 2015).

The establishment of the National Infrastructure Commission (NIC) by the UK government shows that there is an emerging direction of travel consistent with the ideas in the present paper in the UK. NIC is expected to provide expert, independent advice on pressing infrastructure issues, produce an in-depth assessment of the UK’s major infrastructure needs and give advice on how to meet them (HM Treasury 2015).

Although recommendations made by NIC will be based on robust analysis and evidence, and will subject to Parliamentary scrutiny, it is the government who will have the upper hand over what infrastructure projects to be built. This suggests that the introduction of NIC changes structure and actors, but not practice. Therefore, the potential for NIC to improve the process of identifying and delivering infrastructure needs will be low, and the present paper can be considered as a step for improvement.

CONCLUSIONS

The purpose of this paper was to contribute towards improving the identification process of civil engineering infrastructure projects, so that these projects are identified to address societal problems. This aim was achieved by adapting problem solving ideas and incorporating them into the identification process of civil engineering infrastructure projects. The research findings reveal that if civil engineering infrastructure projects are accepted to be solutions to problems, they can be identified through a problem solving process. One of the more significant findings to emerge from this paper is the proposed two-stage identification process. The process brings together infrastructure developers and concerned stakeholders at the earliest stage of the project life cycle to: first agree on the problem to be addressed, generate worthwhile solutions and assess them for consensus or near consensus project that can be implemented with minimal disruption and conflicts. Developing and delivering civil engineering infrastructure projects in this manner ensures that public funds are spent on projects that address clearly legitimate problems, provide the greatest benefits to society, and that they are spent in the most efficient way.

An in-depth evaluation of the proposed two-stage identification process lies outside the scope of this paper. Future studies will consider the benefits of the proposed process and work is currently on-going in this area. The research reported here was conducted in the UK, so its findings may have reflected the UK environment.

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