The Value of Early Warning Systems in Projects;

A Case Study on The Enterprise Centre (TEC) Project at University of East Anglia

Summary

Based on studies on the history of failed projects, it is obvious that projects do not result in failure overnight. In hindsight, project managers are often able to point out the most likely factors leading to project problems. One approach towards prevention of project failure or deviation from the main goal, is to attempt to detect possible signs of project failure in early stages of projects. These signs are referred to in the literature as Early Warning (EW) signs. This paper looks at the application of an EW system in a real-life project and how it contributed to project success. This study builds on the archival data from the project and interviews with 9 key project stakeholders on the benefits of application of the EW system. The findings show that EW systems can enhance collaboration and constructive dialogue among the project team and hence create the opportunity to avoid or mitigate potential risks. It also shows that the openness of the project client and the project team to acceptance of precautions, plays an important role in gaining the most possible benefits from the use of such tools.

Keywords: Early warning system, construction projects, collaborative work, risks

Track: Project Experiences

Word count: 5082

Introduction

Construction projects are often initiated in complex and dynamic environments resulting in circumstances of high uncertainty and risk, which are compounded by demanding time constraints (Jayasudha and Vidivelli, 2016). These projects are perceived to be exposed to higher numbers of risks due to involvement of various contracting parties, such as owners, designers, contractors, subcontractors, suppliers, etc. (PMI 2008). Construction risks need to be proactively managed if the objectives and targets of a construction project are to be achieved (Goh et al., 2013) and therefore, risk management is considered to be a very important managerial process for achievement of project's objectives in terms of time, costs, quality, safety, and environmental sustainability (Rezvani Befrouei and Taghipour, 2015).

Risk management should be applied as an integral part of project management for the successful delivery of construction projects in terms of time, cost, quality, safety, and environmental sustainability (Zou et al. 2007). Early Warning (EW) systems can act a supporting tool to the risk management system and act above the risk register. The value of EW system lies in providing available time for the project team to take preventive actions to manage the potential risks more efficiently (Nikander, 2002). In practice though, not many construction projects apply EW systems as a decision support tool within their risk management process. This can be due to many reasons among which the additional costs the application of such systems adds to the project costs, lack of willingness of project client to hear "bad news" and also lack of an environment of trust where EW signs can be raised by project stakeholders without fear of being labelled as the problem. It is thus important to learn the enablers and barriers to effective applications of EW systems as a means to mitigate potential risks and hence increase the possibility of project success.

This paper discusses the application of an EW system called RADAR in the case of The Enterprise Centre (TEC) at University of East Anglia in the UK. The project is a demonstrative case of effective application of an EW system as a means to create a collaborative environment where all project stakeholders were given a voice to raise their concerns and opinions timely enough for the project team to be able to take action. The main research question this research tends to answer is: *How can EW systems create value for projects?* This paper builds on the theoretical framework of EW systems developed by Nikander (2002) and Hajikazemi (2015).

The remaining sections of this paper include background of research, methodology, findings and finally discussions and conclusions.

Background

Despite the application of project management tools and techniques in projects worldwide, still a large number of projects fail to meet their objectives. Based on studies on the history of failed projects, it is obvious that projects do not result in failure overnight. With hindsight, project managers are often able to point out the most likely factors leading to project failure. One approach towards prevention of project failure or deviation from the main goal is to attempt to detect possible signs of project failure in early stages of projects. These signs are referred to in the literature as Early Warning (EW) signs.

The major challenge for the project managers is the identification of these signs and attempting to respond to them in order to prevent the negative circumstances. Although it is not a proven fact that identification of EW signals is a guarantee against project failure, there are a number of resources which consider paying attention to these signals and attempt to respond to them as a contribution to project success (Hajikazemi, 2015).

While it is always a challenge for projects to identify the chances of risks actualising and how to prevent or avoid their consequences, EW signs adds value to the risk management process by helping the project obtain indications as early as possible of some development that in the future will become clearer, typically of a negative nature. The first discussion about EW in a management context was initiated by Ansoff (1975). This is supported by Nikander (2002) who dealt extensively with this literature in his doctoral dissertation. Ansoff suggested that strategic surprises, for example the oil crisis in the early 1970s, do not appear out of the blue, rather they may be detected by the aid of pre-emptive signs. These signs he called weak signals. A weak signal was defined as "[. . .] imprecise early indications about impending impactful events" (Ansoff and McDonnell, 1990, p. 20). The core idea is thus that even unexpected discontinuities are heralded by some warning signals.

The definition of EW signs is according to Hajikazemi (2015, p.12) *"a specific element, happening or event which shows that the risk event will actually realize. The EW sign does not provide information on the exact time of the materialization of risk; neither does it reveal its expected magnitude. Rather it acts as an alarm which triggers action in order to either prevent the realization of the potential problem or possibly lessen the undesired consequences.".*

It is important to know that EWs do not seem to provide a clear picture of the exact time where the problem might become current. The most that it reveals is that there is little time before the problem materializes. The EW phenomenon is linked to the risk management concept via the concept of "risk symptoms" which has been discussed in PMBOK (2021). Risk symptoms are evidences which reveal that a potential problem will actually materialize. To minimize the damage that the problem causes for the project, responses are required to correct the situation.

However, it is worth mentioning that according to Niwa (1989), the information provided by an EW about the time available before the potential problem becomes real, is not the same thing as the probability of materialization of a risk. These two concepts do not substitute each other and are not opposite factors. Rather they supplement the total knowledge.

Although the concept of EW signs and EW systems are quite well-known and widely implemented in areas such as health (Swanton et al., 2009; WHO, 2022), natural disasters (Basher, 2006; Gasparini et al., 2007), risk and safety (Skogdalen et al., 2011; Zheng et al., 2012) and environmental destruction/ ecosystem collapse (Gourmelon et al.,2010; Lenton, 2011), it is less known and implemented in the project context. According to Nikander (2002), very little existing literature deals explicitly with the EW in projects and project management. The same observation was made by Williams et al. (2012) addressing that this topic is under researched. In the recent years however, more attention has been paid to this phenomenon and its potential benefits for projects and in particular construction. According to Meng (2014), there is a significant difference between the performance of construction projects that use EW systems and those that don't, in terms of time, cost, and quality. EW systems prove to be an important approach of proactive management during a construction or engineering project (Meng, 2014). Kim et al. (2018) propose an early-warning performance monitoring system (EPMS) is proposed to objectively measure and monitor the performance of a project for early detection of inherent poor performance problems. The reason for this concept being bold in this sector can be the fact that very often, construction projects are completed with high cost overrun, extended deadlines and significant quality issues (Giegerich, 2002).

EW signs can be detected and analysed via a range of different tools. The project management literature includes some directed references and some indirect references to tools which can be used as EW sources. Examples of direct mentions are project success / failure models (Pinto and Slevin 1988; Lewis 1993; Miller and Lessard 2000; Sjekavica Klepo and Radujković

2019), Project assessment methods (Miller and Lessard 2000; Wateridge 2002; Cooper 2005; Jaafari 2007; Williams et al., 2012). Different tools may also focus on different areas of risk. For example, the earned value method focuses on identifying early warning signs of deviations from cost and time baseline plans (Kim, 2014). While other methods such as project health check might have a more general view on all areas which might expose the project to risk including managerial risks (Jaafari, 2007; Hajikazemi and Anderson, 2014). This paper will focus on a case study of application of an EW system aiming at identifying behavioural risks in a project setting.

Methodology

The aim of this study is to understand the benefits of implementation of EW systems in projects. To fulfil this, a real case project which successfully implemented an early warning system called "RADAR" was studied. The project included the building of The Enterprise Centre (TEC) at the University of East Anglia (UEA) in the UK. The implementation of the tool, which will be discussed in this section, proved to add value by enabling the project team to tackle issues early and thus reduce conflict which ultimately led to saving time and money (APM, 2018).

This study applies case study research in order to scrutinize how identification and actions on EW signs can be beneficial for projects. With the principles of EW already researched by different authors, the next phase of research is logically the development, implementation, and testing of more specific methods for identifying and acting on EW signs, thus validating EW as a feasible approach to improve project performance. For this type of research, the case study approach which allows better understanding of the concept by thorough examination of specific approaches in practice is a suitable solution (Yin, 2018). A typical case study focuses on what that exemplifies a stable, cross-case relationship (Seawright and Gerring, 2013). The aim for this research was to find a typical case of the application of an EW system so that the usefulness of such systems can be evaluated. There are not many case studies on application of EW systems in the construction sector so this case was among those which the author had access to both archival data and the project stakeholders. This case study was done in order to examine the results of implementation of the tool alongside its potential for improvement. It is important to mention that since the tool is still not well known in the industry, and currently not many firms are applying it, the case study is rather limited. Nevertheless, it has been endeavoured to perform an inductive analysis taking into account all the limitations and constraints.

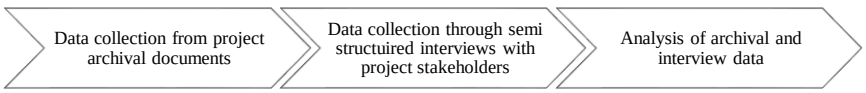

Figure 1. Research design

Case project and the EW system

The project under study is the construction of the sustainably designed enterprise centre at the University of East Anglia in the UK. The project started in Jan 2012 and ran through to May 2015. The project was delivered via a New Engineering Contract (NEC) contract form. A prime contractor was appointed and put in a position where they had full responsibility for the completion of the project, managing all design and construction activity. The NEC form facilitated the concept of all parties working in the spirit of collaboration. The key to the delivery of the scheme was the engagement of all parties in the identification and mitigation of risk. The NEC contract processes and traditional risk management protocols were supplemented by an enhanced early warning mechanism called RADAR (Watson et al., 2018).

The tool is designed to be a collaborative early warning system that identifies risks through real-time risk profiling for assessment and review. It does this by collecting anonymised risk perceptions of project stakeholders and analysing and tracking these by testing and uncovering risk assumptions, in order to provide sufficient warning to enable risk to be minimised. The purpose of the tool was to give a safe and confidential arena in which individual project team members could feedback information about their feelings of different project attributes.

Once a month during asset delivery the wider project stakeholder team received a bespoke questionnaire. This allowed respondents to confidentially express their gut feelings about the pre-defined key performance areas. Collation and analysis of all responses then took place by an expert Panel, all with established industry experience and analytical tools at their disposal to explore this accumulated project feedback. Prior to inclusion in any report individual responses were anonymised. With rapid turnaround, the resulting reports were then shared with everyone in the stakeholder team. The monthly reports presented an overview of perceived risks and issues along with early warning of areas of concern. The core management team then reviewed the report for the month at all the monthly project meetings and more widely at the quarterly continuous improvement workshops (See Table 1). Questions 1 to 9 were common in every round of data collection, however questions 10 to 14 changed referred to higher ranked risks as per the risk register, every month.

Table 1. RADAR questions

No.	Question	Type
Q1	Are there any specific project successes you would like to highlight?	Fixed
Q2	Are there any general comments, specific opportunities or concerns you would like to raise about the project?	Fixed
Q3	The overall stated objective of the project charter is to "exceed expectations"; from progress to date, do you feel the current delivery plan will allow us to exceed expectations?	Fixed
Q4	How do you rate the team's progress towards its stated goal of "perfect delivery" which is described as safe, on time, snag free, with a delighted customer? Would you recommend the team?	Fixed
Q5	Is the project team achieving open and honest communication sufficient to prevent surprises across the whole project team?	Fixed
Q6	Do you feel that the innovations in both design and methods of working are capable of being adopted commercially on other projects?	Fixed
Q7	One of the goals of the project is to deliver long-term benefits to all team members, how do you rate your future benefits?	Fixed
Q8	The project charter commitment to "Developing, maintaining and channelling enthusiasm for, and celebrating successful collaboration". Please rate your experience of the collaborative working practices of the team?	Fixed
Q9	Do you feel the team is effectively mitigating unnecessary risks, within the context of a pioneering project?	Fixed
Q10	*Please rate the following risk: There may be a lack of resource (Funds, time or people) to maintain the Accepted programme.*	*Variable*
Q11	*Please rate the following risk: Inadequate time for costing stage D design*	*Variable*
Q12	*Please rate the following risk: New & unproven combinations of materials requiring specialist testing at early stage in design process*	*Variable*
Q13	*Please rate the following risk: Requirement to provide supplies to Earlham Hall causes conflict with proposed Project Works.*	*Variable*
Q14	*Please rate the following risk: The Works Information (contract requirement) may be subject to uncontrolled Scope Creep.*	*Variable*

Data collection

A prerequisite for attaining robust results from a case study is to have multiple data sources that can be triangulated to ensure the validity of the results (Yin, 2018). For this study, data were gathered from archival material and semi-structured interviews. Since one source of data for this study has been the results of the application of the RADAR tool in the case project, archival material has been significant. The documents include:

- Monthly reports produced as the result if implementation of RADAR (40 reports)
- Published post-delivery reports by the project team on the use of RADAR

Having reviewed the tool and its results and the information available on the project scope and team, an interview guide was designed to obtain data about the benefits of the use of RADAR for this particular project. As the project ended in 2018, access to all project stakeholders was not feasible. The author interviewed 9 project stakeholders to investigate the way the RADAR tool had been implemented in the case project and evaluate its usage as an early warning system. The respondents were chosen among a range of project stakeholders to ensure the representation of as many interests as possible, in the project (Table 2).

Table 2. Participant information

ID	Job title	Role in the project	Years of experience
P1	Chief Executive	External consultant	15-20
P2	Construction risk management consultant	Risk expert	20-30
P3	Senior project manager	Deputy project director	20-30
P4	Construction director	Contract manager	30-40
P5	Employment law crime specialist	Advisor with relation to the EW tool	30-40
P6	Professor	Project director	30-40
P7	Project manager and partner	External project manager	30-40
P8	Director of the Architects Practise	Project Architect Associate	30-40
P9	Project director	Risk expert	30-40

Data Analysis

The data obtained from the archive material and interviews were analysed using a qualitative approach. The data, which presented the results of the use of RADAR in the case project, was used to shed light on the implementation of EW systems in practice and how they are perceived in a real working environment. The monthly reports which included the results from the project stakeholders answering the questions was reviewed and coded based on the type of concerns which were raised.

The information derived from the interviews mainly exhibited the process of implementation of the RADAR tool, together with the benefits, challenges and possible areas for improvement. It also revealed how the utilization of the tool acted as an early warning system and hence contributed to success. The interview results were also coded based on two main thematic categories, including 1) the intention of the tool and how it was supposed to help the project and 2) the extent to which application of the EW system contributed to the success of the project in practice (See Figure 2).

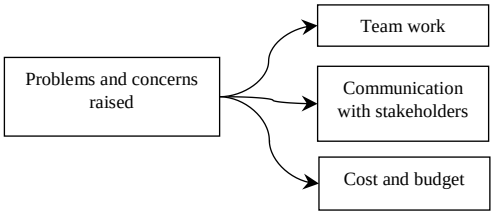

Figure 2a. Coding tree for archival material

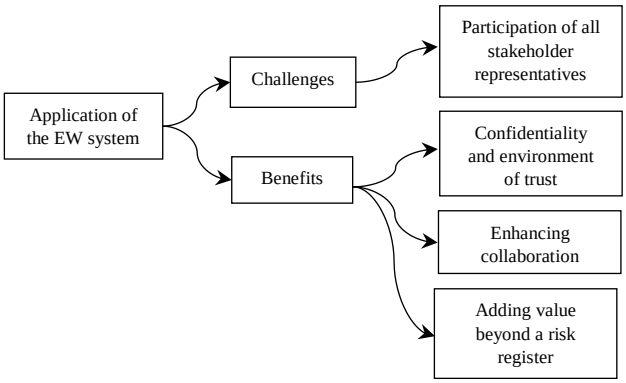

Figure 2b. Coding tree for interview results

Concerning the validity and reliability of this research, the use of secondary data, archival records and documentation, has both upsides and downsides. According to Yin (2018, p. 17) archival analysis in case study research can be used to answer questions as what, how often and when. The use of archival data can also be considered as particularly suitable for studying longitudinal event chronologies (Langley et al., 2013). However, typically archival and documentary data are completed with other types of evidence such as interviews for the purposes of triangulation. As the project was completed approximately 7 years ago, access to all project stakeholders was not an easy option, therefore the data gathered are limited. Since our findings are based on one specific construction organization, and our literature review is primarily focused on the literature addressing the construction industry in specific, our results should not be generalized in a too straightforward manner outside such projects and contexts.

Findings

Archival data

The archival data include the monthly reports and the published material by the project team on the use of RADAR. Through the surveys, the respondents had the chance to 1) discuss particular successes or concerns on the project, 2) express their feelings about the progress of the project and achievement of its goals and 3) rate the risks which varied based on the project stage (these risks were picked up from previous reports). The responses were analysed and outputs and reports to all project stakeholders, including supply chain, were ready within 48 hours of questionnaire deadlines to suit project reporting timelines. This was done with the aim to create time for effective risk evaluation and decision-making to allow early mitigation and responsive action. The next month others would add their weight to this issue either via free text, or via the risk report, if it had been selected as a risk for assessment by the team.

The results showed three main categories of problems which were normally raised by the respondents. Communication with stakeholders and the need for increasing engagement was among the elements continuously raised throughout the process, for example *"Need for early engagement with - stakeholder x- to agree certification process*". Concerns with regards to teamwork was another category of concerns which was mentioned in the reports. An example is *"The loss of a senior member of the construction team with a high level of project knowledge and the challenge for the new project manager of familiarisation with the project and the team's way of working."* Concerns regarding cost and budget were also sought through the survey. Some examples are: "*We continue to be significantly over the set budget, but accept detail costs not are available due to the design stage at present."* and *"Team effort is needed in getting the project back near to budget."*

Apart from the concerns, the responses to questions 3-14 were visualised in a figure where the responses would be RAG (Red, Amber, Green) coded to show the severity of the issues and the attention the team needed to put into that area to avoid it from becoming an issue. A research done by the project team 3 years after the completion of the project (Watson et al., 2018) showed that certain risks were identified 6-9 months in advance and through the use of the tool and hence provided the possibility for the team to take corrective actions. Examples are potential stifling of innovation of new and unproven materials, lack of effective team engagement leading to potentially missing clear understanding of stakeholder expectations and programme impact of design issues and design delays arising from late decision making. These elements were then added to the survey as potential risks and the weight was assessed from all project stakeholders' perspective. The most important risks were chosen by the analysing team to be added in the executive summary report. Corrective actions were then taken in a timely manner to mitigate these risk. The visualization of the results as trend lines provided further opportunity for the project team to monitor the proximity and severity of the risks.

Interview results

The interviews were performed in 2021, with a wider range of stakeholders and with the aim to evaluate the usefulness of the EW tool (RADAR), with the case project as a demonstrative case.

The interview results focused on the process of collecting data from the case project's stakeholders through RADAR, the final product of the survey (monthly reports and executive summaries) and the perception of interviewees on the benefits of the use of the tool and how it contributed to overall project success. The findings presented here are elements which were mentioned by the majority of interviewees. Specific quotes have been presented as examples of statements.

The interviewees described various elements when they were asked about the value the application of this tool brought to the project. They believed the value of the tool lied in the dynamism of the tool and the way the data obtained was analysed through both judgements of an independent and project-neutral experienced panel and the workshops and follow-up meetings which provided the opportunity for all participants in the process to clearly understand the process and the data analysis results and also clarify any points which might have been missed. The facilitated workshops **enhanced collaboration** through creating an open environment where all parties (respondents to the survey) could elaborate on their points if they wished to. According to P3 *"Somebody in - in the meeting who - who's quiet, reserved, shy might have one of the best ideas in the room, but they're too intimidated to say it and bring that across in a meeting. That's where the tool helped. It also meant that the - the one strong opinion wouldn't be carried through because it would be diluted by other people's views. So, it acted as a good barometer for levelling out opinion more than listening to the one person who was loudest in the room."* The interviewees also emphasized the importance of the tool as a means to flag whether collaboration among the team was effectively in place. P6 mentioned *"Collaborative working is essential to lead a really complex, multifactorial projects. If collaborative working breaks down, you need to know about it immediately because that's where the project will start to fail. So the tool's closest value is working out when the team was functioning properly and when the team wasn't."*

The workshops were held in locations outside the project environment to create an environment of **neutrality and trust** for the participants to discuss the results of the survey and make effective decisions to respond to potential risks. According to P4 *"It was all about knowing how people felt, because you never knew what the quiet one in the corner was thinking, but*

they probably are the person or persons that had the - the better knowledge, the better feedback, but they were too shy to say anything!"

The fact that the project stakeholders had the opportunity to express their feelings and perceptions confidentially and that project problems were raised by an external party, contributed to obtaining a range of views and opinions about the project progress. In a situation where the external and independent party was not involved, the project team might have avoided to voice their opinion. It also created environment of trust and According to P1 "*We are taking the most difficult topics away from being presented by a person at the table to being presented by an external party. Now, at that point, I become the common enemy of that project which I'm fine with because your enemy's enemy is your friend and therefore what that allows is a different approach to solution creation to problem solving*".

Another value of the tool was the **dynamism of the tool** and the fact that the questions changed throughout the process. The risk register was updated based on the risks which were raised by the participants. The top 5 risks on the risk register would then go on the survey (Q9-Q14) and the participants got to rank them based on their perception of the severity of the risk for the project at the time of data collection. It is however worth mentioning that the tool added additional value to the risk management process. P1 mentioned *"It wasn't a hands-off digital solution. It was a human service that utilised technology for effective data gathering rather than communication."*

The interviewees also mentioned a number of challenges when it came to the effective use of the tool among which the response rate from those stakeholders who were asked to participate in the survey. In addition, the buyout from the client is an important element which affects the usefulness of this tool. It in fact requires the project client to believe in transparent and open communication and not be afraid of "bad news". In that case the tool can be of help to the project. Another challenge is when projects do not have a clear base line as the tool is designed to flag possible deviations from the baselines and hence can be distorted if that is not in place.

Discussion and conclusions

Early warning signs are often confounded with risks, in a project setting. In reality, they are more than that and can in fact create the opportunity for the project team to take preventive and corrective actions timely enough successfully manage potential risks. They also create value by providing the chance for a more dynamic and collaborative risk management process and hence securing higher rate of project success. The case study presented in this paper confirms the value brought by application of an EW systems (RADAR) as a tool for proactive management of a complex construction project (Meng, 2014).

According to the key stakeholders of this project, the value of this tool lied in the fact that it opens up for discussions around raised issues timely enough for the team to be able to make corrective actions. It also created an environment where all opinions (even the opinions of those who were not dominant actors in the project) could be sought and heard and hence reducing possible biases. According to Williams et al. (2012), many early warning signs are of a less measurable nature and thus depend on more "gut feeling" approaches. The RADAR tool recognizes this by asking questions which are focused on how project team "feel" about the project progress or other project-related elements.

This is particular relevant in the construction sector where complexity of projects is high due to the network of suppliers involved (Pryke, 2012). In addition, these projects are often facing more and greater risks and need more effective methods and tools to manage them, due to their high level of complexity, size and duration (Sun et al., 2015). Use of EW systems is one of the

proactive approaches for better management of such risks. It is worth mentioning however that there are always challenges for transforming an EW sign into a practical response. Although there is evidence that it is possible to detect EW signs in projects and despite the existence of the necessary information, in many cases the appropriate response is missing. This may be due to many reasons, such as time pressure, a tendency for optimism, and the effects of politics (Williams et al., 2012), over-optimism, lack of tolerance of warnings, and lack of an outside view (Lovallo and Kahneman, 2003), or the 'normalization of deviance' (Pinto, 2013). It is thus important that the design of EW tools and the way data on potential EW signs is collected, analysed and communicated to the project team enables reduction of biases. The RADAR tool according to the research participants interviewed, enabled the project stakeholders to express their opinion and feelings about a wide range of areas within the context of the project. In addition, the follow up workshops provided the opportunity for all participants and the project team to discuss their ideas in a collaborative environment in order to come to a risk response which would take into account different stakeholder interests, in a timely manner.

Apart from the biases of project stakeholders, the willingness of the project client to apply an EW system in their project is a key success factor. In the case discussed in this paper, the client was open to the use of the EW system with the view to create value for all project stakeholders. This might not be the case in all projects as sometimes decision maker and political filters (Hajikazemi, 2015) can act as a strong barrier to taking appropriate actions in response to an identified EW sign. In addition, in a setting where an environment of mutual trust for the stakeholders to work collaboratively, has not been created by the project client, some EW signs will not even be raised.

This research has had some limitations which might have affected the findings. The case project ended in year 2015 and the interviews performed were done in 2021. Due to this gap, access to all stakeholders involved in the project was not feasible. Naturally, access to a wider range of stakeholders would have provided a more comprehensive overview of the stakeholders' perception of the usefulness of the tool. In addition, the time past might have affected accuracy of data as in some cases, the interviewees responded to some questions based on their memory.

Further research can be done on how EW tools can be designed and promoted in a way that their value is seen beyond being a whistle blowing tool but rather a proactive and collaborative approach to managing risks. Further research on the use of EW systems in projects outside the construction and infrastructure setting would also be of interest.

References

Ansoff, H.I. (1975) Managing strategic surprise by response to weak signals. California Management Review, XVII (2), 21–23.

Ansoff, H.I. and McDonnell, E.J. (1990) Implanting Strategic Management (2nd Ed.), Prentice- Hall International, Cambridge, England.

Association for Project Management (APM) (2018) On the radar, Project Magazine by Association for Project Management (APM), Spring 2018: 58-59.

Basher, R. (2006) Global early warning systems for natural hazards: systematic and people centred,
Philosophical Transactions of Royal Society, 364, 2167–2182.

Cooper, R.G. (2005) Product Leadership: Pathways to Profitable Innovation (2nd Ed.), Basic Books, New York.

Gasparini, P., Manfredi, G., Zschau, J. (2007) Earthquake early warning systems, Springer, Berlin.

Giegerich, D.B. (2002) Early warning signs of troubled projects, AACE Int. Trans., Proc., 46th AACE Int. Meeting, Portland, Ore., CDR.2.1–CDR.2.8.

Goh, C.S., Abdul-Rahman, H. and Samad, Z.A. (2013) Applying Risk Management Workshop for a Public Construction Project: Case Study, Journal of Construction Engineering and Management 139(5): 572-580.

Gourmelon, M., Lazure, P., Hervio-Heath, D., Le Saux, J.C., Caprais, M.P., Le Guyader, F.S., Catherine, M., Pommepuy, M. (2010) Microbial modelling in coastal environments and early warning systems: useful tools to limit shellfish microbial contamination, World Health Organization (WHO). Safe Management of Shellfish and Harvest Waters, IWA Publishing, London, UK.

Haji-Kazemi, S. and Andersen B. (2014) Efficiency of project health checks (PHCs) as an early warning system in practice: a case study in Norway's telecommunication industry. International Journal of Managing Projects in Business 7(4): 678-700.

Hajikazemi, S. (2015) The Early Warning Procedure in Projects; Foundations, Approaches and Challenges, Doctoral dissertation, Norwegian University of Science and Technology (NTNU), Trondheim, Norway.

Jaafari, A. (2007) Project and program diagnostics: A systemic approach. International Journal of Project Management, 25(8): 781–790.

Jayasudha, K. and Vidivelli, B. (2016) Analysis of Major Risks in Construction Projects, ARPN Journal of Engineering and Applied Sciences, 11(11): 6943-6950.

Kerzner, H. (2017) Project management: A systems approach to planning, scheduling and controlling (12th Ed.), Van Nostrand Reinhold, New York, US.

Kim B. (2015) Dynamic Control Thresholds for Consistent Earned Value Analysis and Reliable Early Warning, Journal of Management in Engineering 31(5): 04014077.

Kim, C., Yoo, W.S., Lim, H., Yu, I., Cho, H. and Kang, K. (2018) Early-warning performance monitoring system (EPMS) using the business information of a project, International Journal of Project Management 36 (5): 730-743.

Langley, A., et al. (2013) Process studies of change in organization and management: unveiling temporality. Academy of management journal, 56 (1): 1–13.

Lenton, T.M. (2011) Early warning of climate tipping points, Nature Climate Change,1, 201–209.

Lewis, J.P. (1993) The project manager’s desk reference. Probus, Chicago.

Lovallo, D. and Kahneman, D. (2003) Delusions of success: How optimism undermines executives’ decisions. Harvard Business Review, July 2003, 56–63.

Meng, X. (2014) Is Early Warning Effective for the Improvement of Problem Solving and Project Performance? Journal of Management in Engineering 30(2): 146-152.

Miller, R. and Lessard, D.R. (2000) The strategic management of large engineering projects: shaping institutions, risks, and governance. MIT Press, Cambridge, MA.

Nikander, I.O. (2002) Early warnings: A phenomenon in project management, Doctoral dissertation. Helsinki University of Technology, Espoo, Finland.

Niwa, K. (1989) Knowledge-based risk management in engineering, Wiley, New York.

Pinto, J.K. and Slevin, D.P. (1988) Critical success factors across the project life cycle. Project Management Journal, 19(3): 67–75.

Pinto, J.K. (2013) Project management, governance, and the normalization of deviance, International Journal of Project Management, 32(3): 376–387.

Project Management Institute (PMI) (2021) A guide to the project management body of knowledge (PMBOK® guide), 6th Edition, Newtown Square, PA, USA.

Pryke, S. (2012) Social Network Analysis in Construction, Chichester: Wiley-Blackwell.

Rezvani Befrouei, M.A. and Taghipour, M. (2015) Identification and Management of Risks in Construction Projects, American Journal of Civil Engineering 3(5): 170-177.

Seawright, J. and Gerring, J. (2013), Case Selection Techniques in Case Study Research: A Menu of Qualitative and Quantitative Options, Political Research Quarterly 61(2): 294-308.

Sjekavica Klepo1, M. and Radujković, M. (2019) Early Warning System in Managing Water Infrastructure Projects, Journal of Civil Engineering and Management 25(6): 531–550.

Skogdalen, J. E., Utne, I. B. and Vinnem, J. E. (2011) Developing safety indicators for preventing offshore oil and gas Deepwater drilling blowouts, Safety Science 49, 1187-1199.

Sun, C., Qingpeng, M. and Yaowu, W. (2015) Study on BIM-based construction project cost and schedule risk early warning, Journal of Intelligent & Fuzzy Systems, 29(2): 469-477.

Swanton, R.D.J., Al-Rawi, S. and Wee M. Y. K. (2009) A national survey of obstetric early warning systems in the United Kingdom. International Journal of Obstetric Anaesthesia, 18, 253–257.

Wateridge, J., 2002. (Post) project evaluation review. Project Management Pathways. Association for Project Management, High Wycombe, England, 65–1 to 65–12.

Watson, P., Bayfield, R. and Woodward, S. (2018) Optimising Infrastructure Investor Returns – The Innovative Delivery of the Enterprise Centre at The University of East Anglia [White paper], http://3pm.uk.com/wp-content/uploads/2018/03/UEA-case-study-blog-Resolex.pdf.

Williams,T., Klakegg, O.J., Walker, D.H.T., Andersen, B., Magnussen, O.M. (2012) Identifying and acting on early warning signs in complex projects. Project Management Journal 43(2): 37–53.

World Health Organization, 2022. Child maltreatment, Retrieved from: http://www.who.int/mediacentre/factsheets/fs150/en/, 20 January 2022.

Yin, R. K. (2018) Case Study Research and Applications: Design and Methods, 6th Ed., SAGE, LA.

Zheng, G., Zhu, N., Tian, Z., Chen, Y., Sun, B. (2012) Application of a trapezoidal fuzzy AHP method for work safety evaluation and early warning rating of hot and humid environments, Safety Science 50, 228–239.

Zou, P. X. W., and G. Zhang (2007) Managing risks in construction projects: Life cycle and stakeholder perspectives, International Journal of Construction Management 9 (1): 61–77