STRATEGIC MANAGEMENT OF CHANGES IN EDUCATIONAL BUILDING PROJECTS: A TIMELINE-BASED CHECKLIST APPROACH

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Abstract

Strategic management of changes is very significant for all types of construction projects. Project management teams must have the ability to respond to changes effectively in order to minimize their adverse impact on the project. The study focuses on the causes, their frequent effects and effective controls for changes in educational building projects. To achieve the study objectives, a questionnaire survey was carried out to collect relevant information. Through the literature review, 53 causes, 16 effects and 30 potential controls for change orders were identified. These provided the basis for the formulation of the questionnaire. Responses from 92 professionals who were involved in the educational projects in Singapore were analyzed. They included 28 developers, 33 consultants and 31 contractors. From the survey findings, the most important causes of changes were identified. The study revealed the most frequent effects and most effective controls for each cause of change order. Arising therefrom, a comprehensive tabulation of the 53 causes and their frequent effects and effective controls was also developed. A timeline for implementing the controls was developed through in-depth interviews with the professionals. The study would assist building professionals in taking proactive measures for reducing change orders for educational buildings; furthermore, the timeline would also be helpful for them to implement controlling strategies at the appropriate time. Recommendations were suggested based on the research findings.

Keywords: changes, causes, effects, controls, timeline, checklist, Singapore.

1. Introduction

Changes are common in all types of construction projects (CII, 1994a; Ibbs, *et al.,* 2001). Proper management of change orders is very significant for all types of construction projects. The need to make changes on a construction project is a matter of practical reality. Even the most thoughtfully planned project may necessitate changes due to various factors.

Construction changes are a major source of construction disputes (Fisk, 1997). In general, change orders are perceived to reflect flaws in the planning, design, or execution of a project (O'Brien, 1998). The construction process can be influenced by changing variables and unpredictable factors that could result from different sources (Mendelsohn, 1997). There are many reasons for issuing change orders in the construction process. It can be a result of the non-availability or slow delivery of required materials or the correction of contract document errors and omissions. Identifying the possible controls for change orders is important to avoid potential changes in future projects or to minimize their effects. Kumaraswamy, *et al.* (1998) studied claims for extension of time due to excusable delays in Hong Kong's civil engineering projects. Their findings suggested that 15-20% time over run was caused mainly by inclement weather. 50% of the projects surveyed were delayed because of changes.

The nature and frequency of changes can vary from one project to another depending on various factors. Changes in construction projects can cause substantial adjustments to the contract duration, total direct and indirect costs, or both (Ibbs, 1997). Project management teams must therefore have the ability to respond to changes effectively in order to minimize their adverse impact on the project. The effective management of change orders requires a comprehensive understanding of the root causes of changes and their potential downstream effects (Ibbs, *et al.*, 2001). Hence, it is important to determine the potential causes, their relevant effects and possible controls for changes orders. A checklist of the possible causes, their effects and suggested controls would be helpful in taking proactive and timely measures for reducing change orders for educational building projects. The objectives of this study are therefore to:

a. Identify and examine the potential causes, their effects and controls for change orders for educational building projects in Singapore.
b. Develop a checklist for use by practitioners in implementing the controlling strategies for reducing changes in educational building projects.

2. Causes, Their Effects and Controls for Change Orders

To overcome the problems associated with changes to a project, the project team must be able to effectively analyze the variation and its immediate and downstream effects (CII, 1994a). To manage a variation means being able to anticipate its effects and to control, or at least monitor the associated cost and schedule impact (Hester, *et al.*, 1991). Hence, the causes, their frequent effects and possible controls were presented in this paper. Through an extensive literature review, a list of 53 possible causes of changes, 16 effects and 30 controls was identified. These will form the basis for the survey of the developers, consultants and contractors later. Furthermore, the 53 causes were grouped under four categories: Owner related changes, Consultant related changes, Contractor related changes and Other changes.

2.1 Owner related changes

This section enumerates the causes of changes that were initiated by the owner. In some cases, the owner directly initiates changes or the changes are required because the owner fails to fulfill certain requirements for carrying out the project:

1. Change of plans or scope by owner
2. Change of schedule by owner
3. Owner's financial problems
4. Inadequate project objectives
5. Replacement of materials or procedures
6. Impediment in prompt decision making process
7. Obstinate nature of owner
8. Change in specifications by owner

2.2 Design Consultant related changes

This section enumerates the causes of changes that were initiated by the design consultant. In some cases, the consultant directly initiates changes or the changes are required because the consultant fails to fulfill certain requirements for carrying out the project:

9. Change in design by consultant
10. Errors and omissions in design
11. Conflicts between contract documents
12. Inadequate scope of work for contractor
13. Technology change
14. Value engineering
15. Lack of coordination
16. Design complexity
17. Inadequate working drawing details
18. Inadequate shop drawing details
19. Consultant's lack of judgment and experience
20. Lack of consultant's knowledge of available materials and equipment
21. Honest wrong beliefs of consultant
22. Consultant's lack of required data
23. Obstinate nature of consultant
24. Ambiguous design details
25. Design discrepancies (inadequate design)
26. Noncompliance design with government regulations
27. Noncompliance design with owner's requirement
28. Change in specifications by consultant

2.3 Contractor related changes

This section enumerates the causes of changes that were related to the contractor. In some cases, the contractor may suggest changes to the project or the changes may be required because the contractor fails to fulfill certain requirements for carrying out the project:

29. Lack of contractor's involvement in design
30. Unavailability of equipment (lack of equipment)
31. Unavailability of skills (shortage of skilled manpower)
32. Contractor's financial difficulties
33. Contractor's desired profitability
34. Differing site conditions
35. Defective workmanship
36. Unfamiliarity with local conditions
37. Lack of a specialized construction manager
38. Fast track construction
39. Poor procurement process
40. Lack of communication
41. Contractor's lack of judgment and experience
42. Long lead procurement
43. Honest wrong beliefs of contractor
44. Complex design and technology
45. Lack of strategic planning
46. Contractor's lack of required data
47. Contractor's obstinate nature

2.4 Other changes

This section enumerates the causes of changes that were not directly related to the participants:

48. Weather condition
49. Safety considerations
50. Change in government regulations
51. Change in economic conditions
52. Socio-cultural factors
53. Unforeseen problems

The above mentioned causes of change orders were identified earlier and discussed by many researchers (CII, 1990; Thomas and Napolitan, 1994; Clough and Sears, 1994; Fisk, 1997; Ibbs, *et al.*, 1998; O'Brien, 1998; Mokhtar, *et al.*, 2000; Gray and Hughes, 2001; Arain, *et al.*, 2004; Arain and Low, 2005a; Arain and Low, 2006a).

Effects of change orders were identified and discussed by many researchers (CII, 1986; CII, 1990; Clough and Sears, 1994; CII, 1994a; Thomas and Napolitan, 1995; Fisk, 1997;

Ibbs, *et al.*, 1998; Arain and Low, 2005b). The 16 effects identified from the literature review are enumerated below:

1. Progress is affected but without any delay
2. Increase in project costs
3. Hiring new professionals
4. Increase in overhead expenses
5. Delay in payment
6. Quality degradation
7. Productivity degradation
8. Procurement delay
9. Rework and demolition
10. Logistics delays
11. Tarnish firm's reputation
12. Poor safety conditions
13. Poor professional relations
14. Additional payments for contractor
15. Disputes among professionals
16. Completion schedule delay

Controls for changes and change orders were suggested by many researchers (Mokhtar, *et al.*, 2000; Ibbs, *et al.*, 2001; Arain and Low, 2003; Arain and Low, 2005c; Arain and Low, 2006b). 30 controls that have been identified from a literature review are enumerated below:

1. Clarity of change orders procedures
2. Written approvals
3. Change order scope
4. Prompt approval procedures
5. Ability to negotiate variation
6. Variation logic and justification
7. Valuation of indirect effects
8. Review of contract documents
9. Freezing design
10. Value engineering at conceptual phase
11. Team effort by owner, consultant and contractor to control change orders
12. Utilize work breakdown structure
13. Project manager from an independent firm to manage the project
14. Involvement of professionals at initial stages of project
15. Owner's involvement at planning and design phase
16. Restricted pre-qualification system for awarding projects
17. Involvement of contractor at planning and scheduling process
18. Owner's involvement during construction phase
19. Continuous coordination and direct communication
20. Control the potential for change orders to arise through contractual clause
21. Thorough detailings of design
22. Clear and thorough project brief
23. Avoid use of open tendering

24. Use of project scheduling/management techniques
25. Comprehensive site investigation
26. Comprehensive documentation of change order
27. Reducing contingency sum
28. Use of collected and organized project data compiled by owner, consultant and contractor
29. Knowledge-base of previous similar projects
30. Comprehensive analysis and prompt decision making through computerized knowledge-based decision support system

The abovementioned potential controls were identified earlier and discussed by many researchers (CII, 1990; CII, 1994; CII, 1994a; Assaf, *et al.*, 1995; Chan and Yeong, 1995; Cox, 1997; Fisk, 1997; O'Brien, 1998; Mokhtar, *et al.*, 2000; Ibbs, *et al.*, 2001; Arain and Low, 2003; Arain, *et al.*, 2004; Arain and Low, 2005c; Arain and Low, 2006b). The abovementioned causes, effects and controls will not be elaborated in this paper given the space constraint.

3. Scope of Research

The government of Singapore initiated a major program of rebuilding and improving existing educational buildings to ensure that the new generation of Singaporeans would get the best opportunities to equip them with the information technology (IT) available. A total of about 290 educational buildings will be upgraded or rebuilt by a government agency over a period of seven years, at an estimated cost of S$4.46 billion from 1999 to 2005 (Note: at the time of writing, £ 1 is about S$ 3.30). The study will contribute towards the better control of change orders. Hence, this study concentrated on the educational building projects under this major rebuilding and improvement programme in Singapore. The survey was restricted to the developers, consultants and contractors who were involved in these educational projects.

4. Research Methodology

Through an extensive literature review, the 53 causes, their 16 potential effects and 30 controls for change orders were identified. These provided the basis for the formulation of a questionnaire.

A survey of 178 professionals, who have carried out the educational projects under the rebuilding and improvement programme, was carried out. They included directors, senior managers, project managers and project officers from the developer's side, directors, principal architects, senior architects and project architects from the consultant's side, and directors, senior project managers, project managers and construction managers from the contractor's side. A 5-point Likert scale was used in the questionnaire to gauge the most important causes, their effects and controls for change orders for the educational building projects in Singapore.

In addition to sending out the questionnaires, 40 face-to-face interviews using the questionnaire and the data collected were also conducted to ensure that all questions were answered, to ensure that the information was accurate and the respondents have a chance to clarify any doubts with the research team. Interviews of 20 professionals with the government agency responsible for the rebuilding and improvement programme, 10 consultants and 10 contractors, who were involved in these educational projects, were carried out. The interviewees included those with the senior designations mentioned above for the survey.

5. Analysis of Results

98 professionals responded to the survey. After checking through the completed questionnaires, 92 questionnaires were found to be suitable for data analysis. This yielded a response rate of about 51.69%. Of the 92 respondents, 28 were developers, 33 were consultants and 31 were contractors.

The questionnaire listed 53 causes, 16 effects and 30 controls for changes orders for educational buildings. Each respondent was asked to rate each issue based on his/her professional judgment. The causes of change orders were analyzed and ranked according to their responses. As shown in Table 1, the 53 causes of change orders were tabulated according to their means and standard deviations. This analysis assisted in revealing the most important causes of change orders.

Table 1: Mean and standard deviation of causes of change orders

S/No.	Causes	Mean	Std. Dev.
1	Change of plans or scope by owner	3.40	1.12
2	Change of schedule by owner	2.61	1.26
3	Owner's financial problems	1.88	1.01
4	Inadequate project objectives	2.43	1.51
5	Replacement of materials or procedures	2.68	0.97
6	Impediment in prompt decision making process	2.46	0.89
7	Obstinate nature of owner	1.91	0.93
8	Change in specifications by owner	3.49	1.19
9	Change in design by consultant	3.14	1.12
10	Errors and omissions in design	3.53	1.14
11	Conflicts between contract documents	3.22	1.15
12	Inadequate scope of work for contractor	2.97	1.35
13	Technology change	2.26	0.94
14	Value engineering	2.50	1.11
15	Lack of coordination	3.15	1.19
16	Design complexity	2.65	1.04
17	Inadequate working drawing details	3.13	1.17
18	Inadequate shop drawing details	2.87	1.11
19	Consultant's lack of judgment and experience	2.73	1.05
20	Lack of consultant's knowledge of available materials and	2.54	1.24

S/No.	Causes	Mean	Std. Dev.
	equipment		
21	Honest wrong belief of consultant	2.30	0.92
22	Consultant's lack of required data	2.61	1.25
23	Obstinate nature of consultant	2.07	0.89
24	Ambiguous design details	3.02	1.12
25	Design discrepancies (Inadequate Design)	3.36	1.21
26	Noncompliance design with govt. regulations	3.01	1.24
27	Noncompliance design with owner's requirement	2.84	1.08
28	Change in specifications by consultant	3.03	1.09
29	Lack of contractor's involvement in design	2.88	1.34
30	Unavailability of equipment	2.23	1.00
31	Unavailability of skills	2.24	1.00
32	Contractor's financial difficulties	2.59	1.03
33	Contractor's desired profitability	2.71	1.08
34	Differing site conditions	3.27	1.15
35	Defective workmanship	2.83	1.02
36	Unfamiliarity with local conditions	2.13	1.02
37	Lack of specialized construction manager	2.25	1.13
38	Fast track construction	2.64	1.13
39	Poor procurement process	2.42	1.01
40	Lack of communication	2.91	1.08
41	Contractor's lack of judgment & experience	2.71	1.03
42	Long lead procurement	2.54	1.03
43	Honest wrong belief of contractor	2.32	0.99
44	Complex design and technology	2.27	0.95
45	Lack of strategic planning	2.71	1.01
46	Contractor's lack of required data	2.53	1.02
47	Contractor's obstinate nature	2.05	0.99
48	Weather conditions	3.03	1.17
49	Safety considerations	3.15	1.00
50	Change in government regulations	3.04	1.06
51	Change in economic conditions	2.60	0.84
52	Socio-cultural factors	2.21	0.79
53	Unforeseen problems	3.41	1.07

Furthermore, the questionnaire responses were used for carrying out cross-tabulation analyses between causes and effects, and between causes and controls. The cross-tabulation analyses assisted in identifying the important cores i.e., the causes and effects, and causes and controls that were considered important by the respondents. The number of responses that rated the causes and effects as important were extracted from the cross-tabulation analysis and used for developing the Relative Importance Index (RII). The RII method was adopted by many researchers (Kometa, *et al.*, 1994; Aibinu and Jagboro, 2002) in earlier studies. The causes and their effects were tabulated according to their RII values. Likewise, the causes and their potential controls were also tabulated according to their RII values. These analyses assisted in identifying the most frequent effects and most effective controls for each cause of change order.

The results in Table 2 indicate that the errors and omissions in design, change in specifications by owner, unforeseen problems, change of plans or scope by owner and design discrepancies were considered as the most important causes of change orders for educational building projects. It was also revealed from the in-depth interview sessions with the professionals that a majority of the educational projects were completed during the initial phases of the programme of rebuilding and improvement, hence large numbers of design changes were expected. This was because during the initial phases of the programme, the user requirements and specifications were not well defined. The project objectives were not very clear and the specifications were not yet finalized by the owner due to time constraints. In addition to these, the time allocated for the design process was insufficient because a large number of projects were targeted during these phases. Hence, the results, as shown in Table 2, were not unexpected. The most important causes, their top 5 frequent effects and top 5 effective controls for change orders are shown in Figure 1. Owner involvement at planning and in the design process was considered as the most effective control for changes in educational projects. It was identified from the in-depth interviews that the owners were not involved during planning and in the design process for educational projects during the initial phases of the programme. Hence, all the professionals recommended the involvement of the owner during these stages. Furthermore, a clear and thorough project brief and thorough detailing of design were also highly recommended as shown in Figure 1. As mentioned earlier, the project objectives were not very clear and the specifications were not yet finalized by the owner due to time constraints. In addition to these, the time allocated for the design process was insufficient because a large number of projects were targeted during these phases. Hence, these recommendations were not unexpected. Knowledge-base of previous similar projects was also recommended by the professionals as one of the most effective controls for change orders. This is because presently the professionals, who are involved with educational building projects, do not have a knowledge-base i.e., the organized detailed information about the changes and change orders in previous projects. It is therefore very difficult for them to learn from previous projects and to take proactive measures for controlling changes in future projects. If professionals have a knowledge-base established based on past similar projects, it would assist the professional team to learn from previous projects and to plan effectively before starting a project, during the design phase as well as during the construction phase to minimize and control changes and their effects. Hence, the professionals recommended a knowledge-base of previous similar projects as one of the most effective controls for changes.

Table 2**:** Most important causes of change orders for educational buildings

S/No.	Causes	Mean	Std. Dev.	Rank
10	Errors and omissions in design	3.53	1.14	1
8	Change in specifications by owner	3.49	1.19	2
53	Unforeseen problems	3.41	1.07	3
1	Change of plans or scope by owner	3.40	1.12	4
25	Design discrepancies (Inadequate Design)	3.36	1.21	5

The top 5 effects and 5 controls for each cause were revealed through the RII values for effects and controls. As a sample shown in Appendix 1, the 53 causes and their top 5 frequent effects and 5 effective controls were tabulated. Furthermore, the timelines for implementing the top 5 controls for each of the causes of change orders were also shown as sample in Appendix 1. The project stages were categorized into 5 stages, namely, feasibility stage, conceptual design stage, design development stage, tendering stage and construction stage. The timeline-based checklist for implementing the suggested controls was developed through in-depth interviews with the professionals. It is recommended that the controls be implemented as early as possible.

6. Application of Research

This is a timely study as the programme of rebuilding and improving existing educational buildings is currently under way in Singapore; it provides the best opportunity to address the contemporary issues relevant to the management of change orders. The study presented in-depth analyses of the causes, their effects and controls for change orders for educational building projects. This would assist professionals in analyzing changes and selecting the most appropriate controls for minimizing change orders. The study is valuable for all the professionals involved with developing the educational projects. A clearer view of the causes and their impacts on the projects will enable the project team to take advantage of beneficial changes when the opportunity arises without an inordinate fear of the negative impacts. Eventually, as shown as sample in Appendix 1, a clearer and comprehensive view of causes, their effects and potential controls will result in informed decisions for effective management of change orders. The timeline-based checklist established for implementing the suggested controls will assist the professionals in taking the appropriate control measures at the appropriate time. Furthermore, considering the fact that the changes are common in all types of construction projects, this study also contributed to effective management of change orders as the list of the 53 causes, their frequent effects and effective controls were tabulated in shown as sample in Appendix 1, can be used by professionals to take proactive measures for reducing and controlling change orders in various other types of residential and commercial projects, etc.

7. Beneficial Outcomes

This paper presents a comprehensive view of the causes, their effects and controls, and the timeline for implementing the controls at an appropriate time for reducing change orders for educational building projects. The study will benefit the professionals involved with educational building projects. The professionals would learn about the root causes of change orders and their downstream effects that would assist in the proactive evaluation of change orders. The study will assist in reducing the number of changes in construction projects by suggesting the effective controls and their timeline for implementing controls. Furthermore, this study also contributed to existing knowledge as the in-depth analyses of the causes, effects and controls for change orders for educational building projects, can be used by future researchers/practitioners to carry out studies on the management and control of change orders in various other types of projects.

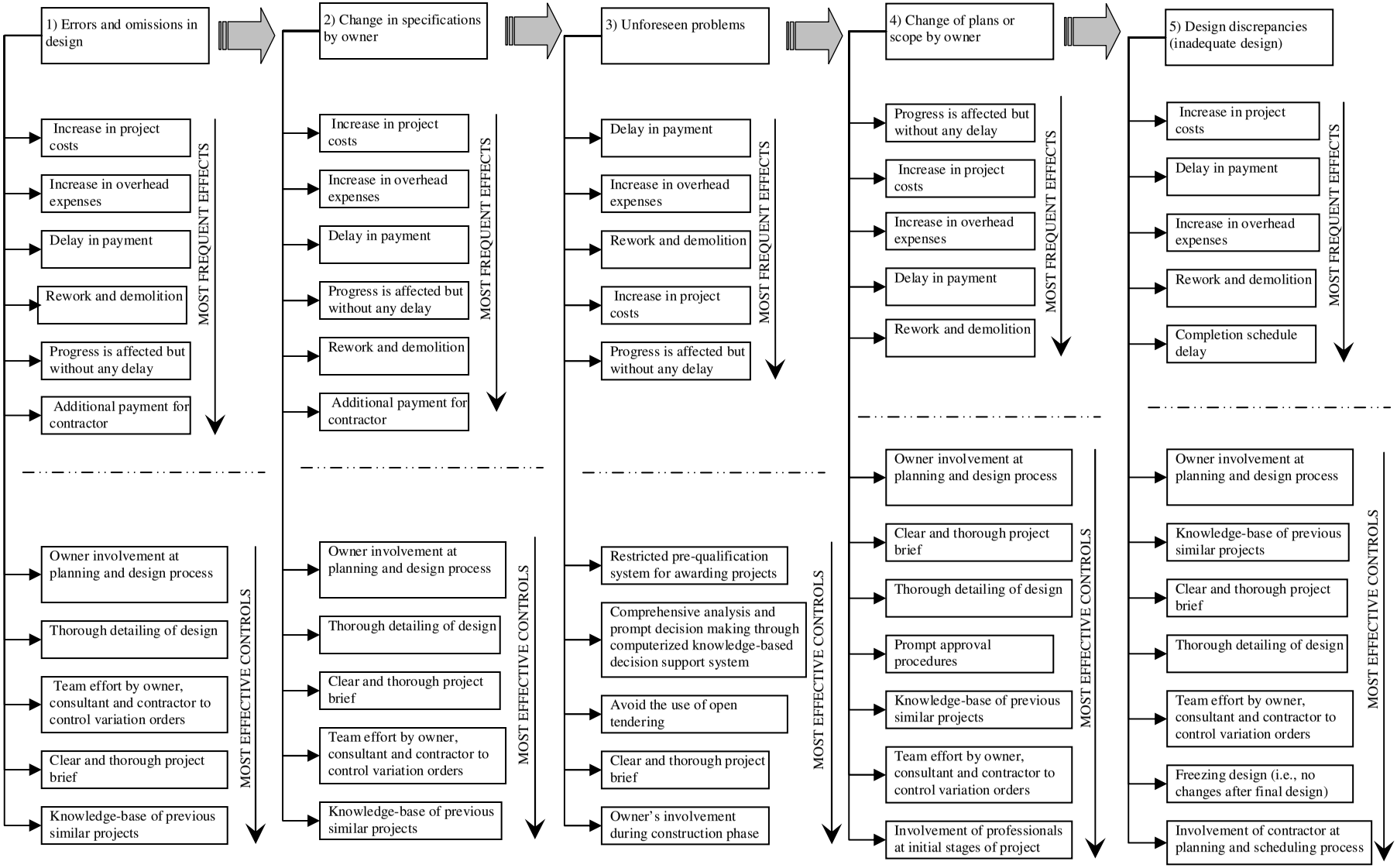

Figure 1: Most important causes, their frequent effects and effective controls for variation orders

8. Conclusions

Through the questionnaire survey and interviews with the professionals who were involved with the educational building projects, the potential causes, their frequent effects and effective controls for change orders for these projects were identified. A timeline-based checklist for implementing each suggested control was also established as shown as sample in Appendix 1. The results in Table 2 indicate that the errors and omissions in design, change in specifications by owner, unforeseen problems, change of plans or scope by owner and design discrepancies were considered as the most important causes of change orders for educational building projects.

As discussed earlier, the most important causes of change orders were mostly owner and consultant related changes. Hence, this study suggests that changes can be reduced with due diligence during the design stages. Also mentioned earlier, in the initial phases of the programme, the project objectives were not very clear, and comprehensive site analyses and design developments were also not carried out due to time constraints. Hence, the above results were not unexpected. Furthermore, the suggested controls, as shown in Figure 1, also emphasized the owner involvement at the planning and design process for a collaborative effort for reducing changes. The design stages were identified as the most potential phases for implementing the suggested controls. Considering the design stages as the most potentially important timeline for reducing and controlling changes, clear and thorough project briefing by the owner and thorough detailings of design by the consultant are highly recommended.

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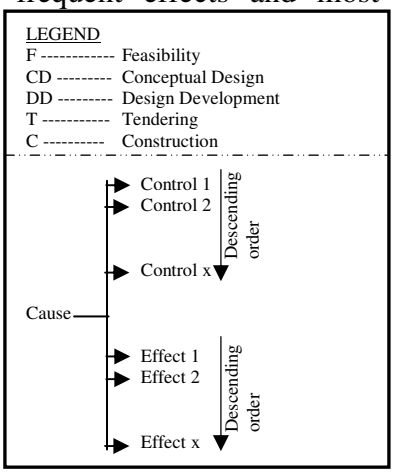
Appendix 1

Timeline-based checklist of the 53 causes, their most frequent effects and most significant effective controls for change orders



S/No	Causes	Controls/Effects	Project Stages				
			F	CD	DD	T	C
01	Change of plans or scope by owner →	→Owner involvement at planning and design process	✓	✓	✓		
		→Clear and thorough project brief	✓	✓			
		→Thorough detailing of design			✓	✓	
		→Prompt approval procedures			✓		✓
		→Knowledge-base of previous similar projects			✓	✓	✓
		→Team effort by owner, consultant and contractor to control change orders			✓	✓	✓
		→Involvement of professionals at initial stages of project		✓	✓		
		→Progress is affected but without any delay					
		→Increase in project costs					
		→Increase in overhead expenses					
		→Delay in payment					
		→Rework and demolition					
02	Change of schedule by owner →	→Involvement of professionals at initial stages of project		✓	✓		
		→Owner involvement at planning and design process	✓	✓	✓		
		→Thorough detailing of design			✓	✓	
		→Clear and thorough project brief	✓	✓			
		→Knowledge-base of previous similar projects			✓	✓	✓
		→Involvement of contractor at planning and scheduling process		✓	✓		
		→Owner's involvement during construction phase				✓	✓
		→Comprehensive analysis and prompt decision making through computerized knowledge-based decision support system			✓	✓	✓
		→Delay in payment					
		→Rework and demolition					
		→Increase in overhead expenses					
		→Progress is affected but without any delay					
		→Increase in project costs					
		→Completion schedule delay					
		→Productivity degradation					

[Given the word limit for this paper, a sample of the timeline is shown]