Complexity and the Process of Selecting Project Team Members

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The sub-process of selecting team members, as in people not organizations, is not applied. It is however a fact that interconnections and boundaries are formed between individuals within a team and teams as a whole within the project and these cause complexity. Complexity characteristics have been identified and if project practitioners understand how these affect the process of selecting team members they will be able to manage its affects. A study was conducted with construction project practitioners from six organizations, which included questionnaires and interviews and investigated the level of implementation of team member selection and the level of actions taken / techniques used to manage the effects of complexity of interconnections. The results concur with previous findings that existing techniques are not implemented but also confirm that the process is not considered as means to manage the effects of complexity. Based on these findings a framework was developed which not only promotes the process and a number of the existing techniques but also enables practitioners to take appropriate action(s) for the management of the effects of complexity of interconnections using its characteristics.

Keywords: complexity, team selection, interconnections, projects, project management.

Introduction

The transient and dynamic environment of construction projects requires the pulling together of individual effort within a team to deliver work packages or for the whole project. Interconnections are formed as individuals and teams from different companies are brought together to deliver the project. These interconnecting structures between the parties result in complexity (Lucas 2000a). Within construction, the management of the category of interconnections complexity is often ignored or at best addressed informally (Lillieskold & Eklstedt 2003). The informal approach to managing the interconnections complexity is due to the lack of clarity on the nature and influences of the characteristics of such complexity in construction (Antoniadis et al. 2006). It is crucial, therefore, to identify and understand the characteristics of complexity, how these are interpreted in the project management environment and what actions / techniques can be used to manage its effects.

Through the process of selecting team members, one of the project management processes with which the project management outcome is measured (Collins & Baccarini 2004); it is acknowledged that individuals and teams form interconnections. Since these interconnections could potentially lead to the creation of complexity it provides justifiable grounds to accept the notion that the selection of team members is critical in managing the effects of complexity which stem from the sub-process of team selection.

In any environment, not only that of construction, the process of selecting team members has been identified as a critical one for forming teams and one of the main supporting techniques is that of personal profiling (Belbin 2004). In the general as well as that in project management literature selection of teams has been presented as a rational activity (Galbraith & Lawler III 2003, Liker 2004, Slevin & Pinto 2004, Turner 1999, Walker 1996). This school of thought considers the selection sub-process as a number of steps which should be implemented to place members within a team. Thompson (1996) and Lawler III (1993) approach the selection of teams from a different perspective by identifying a number of themes or team member characteristics that individuals must exhibit as personal attributes to enhance their suitability for selection into the team. These personality attributes give rise to the formation of boundaries between individuals and within teams, and needs to be managed (Katz & Lazer 2002). However, the construction industry does not pay enough attention to the sub-process of team selection and remains fixed to the rational, resource oriented and transactional approach (Green 2006, Hinds et al. 2000, Ogunlana et al. 2002).

The paper presents the results from a two part investigation, survey and interviews, into the selection of team members and complexity. The survey results indicate and confirm that current techniques for selecting project team members are not implemented for any of the project team levels. The interviews provide evidence that actions taken for managing the effects of complexity, are not to the required level. Using the interview results and contributions from the interviewees a framework was developed which enables project management professionals to manage the effects of complexity for the sub-process of selecting team members.

Review

In the following sections a review of the areas under investigation will be conducted and the multi-method research approach will be described. Following that the results and analysis of the findings from the two-part investigation will be presented and the paper will close with discussion, presentation of the framework developed and conclusions. The review section will be divided into two sub-sections. The first will cover the project management sub-process of team selection, its importance to the project and the current status. The second will cover and assess the area of complexity and its characteristics in the context of project management and in particular the sub-process investigated.

Selection of Team Members

Construction projects are characterized as a temporary endeavor performed in a dynamic environment. The dynamic nature of construction projects creates complications affect the overall performance of the project. A number of authors make references to the dynamic nature of project environments, and recognize the intricacies that arise from the ever-changing conditions projects display during their delivery (Moore 2002, Morris 1994, Muller & Turner 2007, Walker 1996). Antoniadis (2009) having conducted a review of project management definitions suggests that a more 'modern' one should be considered and proposes the following:

> '*The management of transient, dynamic and complex adaptive systems/agents, so as to deliver the expected change within certain parameters that are established by seemingly ordered and stable environments*.'

The definition highlights the fact that project management requires a change in the paradigm and behavioral as well as organizational issues to become the drivers in delivering projects (Courtney & Winch 2003, Slevin & Pinto 2004). These issues form an integral part of the factors that need to be addressed in the selection of the individuals in project teams. Also, both contribute significantly in establishing a favorable team environment consistent with good performance throughout the project. This is reinforced by the marked shift in the industry towards collaborative working and also by the fact that emerging procurement arrangements frequently employ non-pricing criteria to assess contractors (Kadefors 2006). Selecting project team members and the career development of Project Managers (PMs) and project personnel have an important influence in the current collaborative environment (Bourgeon 2006). Also, as highlighted by Walker (1996) effective team selection and formation is a critical determinant for the achievement of project objectives.

The shift towards the behavioral paradigm suggests emphasizes the importance of sub-processes such as selection of project team members which is crucial in the formation of teams (Belbin 2004). This is also highlighted by the comprehensive definition of a team given by Cohen & Bailey (1997) 'a *team is a collection of individuals who are independent in their tasks, who share responsibility for outcomes, who see themselves and are seen by others as an intact social entity embedded in one or more larger social systems, and who manage their relationships across organizational boundaries*'. Assigning individuals to project teams molds the social capital of the organization and therefore we should consider the influence and impact of people allocated to teams as well as the form in which such social capital should be viewed (Katz & Lazer 2002).

However, team formation creates boundaries which consequently generate interconnections. These interconnections / interactions contribute positively or negatively to the network and cultivate a culture of cohesion, trust, sanctions, and other socio-organizational conditions that influence team performance (Katz & Lazer 2002). Therefore, defining the boundaries of the project team, the selection of the team members and the span and integrity of the boundary should form an important consideration in the management of projects. Although it might not be possible to eliminate the evanescent nature of projects, it should be possible to address the transient effect on the boundaries formed through the selection of team members and achieve an acceptable level of performance.

Five key activities are identified for selecting team members (Galbraith & Lawler III 2003, Liker 2004, Slevin & Pinto, 2004, Turner 1999, Walker, 1996). These are:

1. Understand the project needs,
2. Identify and appoint the right project manager,
3. Select team members that meet the needs of the project,
4. Supplement the team with experts to cover gaps in project needs, and
5. Monitor team performance.

From the individual's side and as part of a team, they should:

a. Be creative, open minded and 'forward looking' (Thompson 1996),

b. Be good team players, '*collaborate as members of team*' (Thompson 1996),
c. Use '*judgment*', (Thompson 1996),
d. Be well respected among peers, stakeholders, and other business leaders,
e. Have the '*ability to adapt to change*', (Thompson 1996),
f. Be able to understand, or at least be able to consider, the environment and provide feedback to the team (Antoniadis 1998).

Currently some selection techniques, for certain roles, are used and these are based on job-task and behavioral competencies (Crawford 2005). However, Cheng et al. (2005) emphasize that it is important to understand that competencies are an attribute of both the job holder and the job itself.

Human interaction and team formation is a complex phenomenon (Dal Forno & Merlone 2005). This interaction together with the very short period contractors have to put together the team and the employment of command and control approach to human resource management (Green 2002) obviously does not help the process of selecting project team members. Usually, up to contract award, only the PM would be identified based on a subjective assessment (Ogunlana et al. 2002). The remainder of the team below the PM level would be represented as a lump sum of money and the 'system' would not consider issues relevant to project staffing (Ogunlana et al. 2002). Case studies (Green 2006, Hinds et al. 2000) have shown that selection is race biased and at lowest levels projects are '*structured around nationalities*' (Green 2006).

Concern has been raised regarding lack of implementing the process of team selection as well as how much the management '*scripts*' influence those who do the work (Green 2006). These findings are disquieting, if one is to consider implementing team work principles. Unless of course the team is only considered to be the units at the management system level (Walker 1996). Thus despite all the literature, including the APM BoK (2006) and PMBoK (2000), one could question the level of application of team selection techniques at project level in current practice.

Complexity

It has been well established and for a number of years (Bertelsen 2005, Thompson 1967, Williams 2002) that project management exists in a complex environment and most importantly that '*our project management knowledge base ... does not apply to complex projects*' (Turner 2005). The application of complexity theory and in particular the study of complex adaptive systems is to enable the systematic review of the inter-connections (Baccarini 1996, Lucas 2000a). In projects it is important to define the type of complexity considered (Baccarini 1996). The importance of defining complexity of interconnections in projects is that it can be applied to the numerous project management sub-processes. Selecting project team members, who will resource the various teams and will interconnect, becomes a very critical Project Management sub-process. Baccarini (1996) points out that project complexity influences the selection of project inputs, including the expertise and experience requirements of management personnel.

Analyzing and understanding the effects of the complexity characteristics will enable, the decision-making process, response and output from appropriate actions, improvement of

management of complexity and above all improvement of confidence in the appropriateness of the process. Various characteristics and facets have been described of typical complex systems. For example Davidson Frame (2002) produced four facets of complexity, a) size, b) variety, c) difficulty and d) change. Williams (2002) highlighted uncertainty and structural complexity and at a lower level the interdependence of elements. Kallinikos (1998), on the organization side, identified dynamism, Geraldi (2008) defined patterns of complexity and Crawford (2005) has indicated uniqueness and lack of clarity / definition of scope, goals and methods.
Lucas (2000b) however, having analyzed three systems theories has identified 18 distinct complexity characteristics of which 16 have been considered most relevant to construction project management. The generic description of the characteristics and the authors' conversion of these into project management phraseology are shown in Table 6 (Appendix 1). Antoniadis et al. (2006) classified and grouped these characteristics into three main headings - conditional, developmental and behavioral. Parameterization of these characteristics will enable better identification of actions, improved definition of the boundaries and the interweaving / reciprocity between the project management sub-processes.

As construction moves more towards virtual projects and project team members will be working from different locations, this will demand greater individuality, and consequently creating the need for more teamwork (Edum-Fotwe & McCaffer 2004). As interconnections and networks of communications between team members increase complexity increases, therefore the process of selecting team members and forming teams becomes critical.

The above result in a number of questions being raised in terms of managing complexity of interconnections in projects:

- Do construction companies – clients or contractors – or their PMs consider any team selection techniques?
- Do they follow / implement any of the existing techniques?
- Do they consider complexity of interconnections or its characteristics when selecting team members?

Research Method

The review provided strong indications regarding the implementation of appropriate team member selection techniques in construction projects. This coupled with the established view that construction projects are immersed in a complex environment led in the formulation of the following hypotheses as part of a wider research into complexity in construction.

Hypothesis 1: Project team members are selected using personal profiling
Hypothesis 2: Complexity characteristics are considered when selecting project team members.

The breadth and depth of the issues and the topics under investigation demanded the design and implementation of a multi-methodology research design. In order to investigate hypothesis 1 it was considered appropriate to conduct a postal survey. In terms of hypothesis 2 and because of the intricacies of the subject of complexity and its characteristics it was considered appropriate to conduct open-structured but closed response interviews. The interviews investigated the current

understanding of complexity, its characteristics, and the implementation of techniques that will manage the effects of complexity.

Questionnaires for both hypotheses were prepared and piloted with 10 professionals from three organizations and minor corrections were made. In order to consider both sides of a project the stratified sampling technique was followed with the two main strata – client and contractor. The strata comprised of three major construction client organizations and three major construction companies. For hypothesis 1 postal questionnaires were issued to the Project Management divisions which encompassed professionals from Site Manager to Project Director level. For hypothesis 2, the investigation on complexity, 31 interviews were set up from the organizations that participated in the survey and again with the same levels of professionals.

Hypothesis 1 was operationalized by establishing a level of understanding of awareness, guidance received and implementation of personal profiling techniques for selecting team members and thus formulating three sub-hypotheses which investigated implementation of personal profiling techniques for selecting team members and possible variance between client and contractor PMs in the approach followed. Therefore the following sub-hypotheses were defined:

- Sub-hypothesis H1.1: Companies provide guidance and implement personal profiling techniques when selecting PMs.
- The null hypothesis is that organizational guidance given for using personal profiling to select PMs is not implemented (zero use).
- Sub-hypothesis H1.2: Companies provide guidance and implement personal profiling techniques when selecting site team members.

- The null hypothesis is that organizational guidance given for using personal profiling to select site team members is not implemented (zero use).
- Sub-hypothesis H1.3: There is a difference between client and contractor PMs in the use of personal profiling techniques as selection criteria for project team members to the lowest project organizational level.
- The null hypothesis is that there is no (zero) difference in the use of the personal profiling techniques between client and contractor PMs.

The survey addressed also issues regarding the organizational depth to which selection techniques are implemented. That is, if practitioners implement selection techniques to the lowest project team organizational level.

Similarly hypothesis 2 was operationalized by establishing a response greater than 75 points (from a scale of 0 to 100) of the average weighted effectiveness of the actions taken towards managing the effect of each complexity characteristic. Therefore for each complexity characteristic the following sub-hypothesis was investigated:

- Sub-hypothesis H2.1: The average weighted effectiveness of the actions taken to manage the effects of the complexity characteristic, when selecting project team members, exceeds a level of 75 points in a scale of 100 points.

- The null hypothesis is that the average weighted effectiveness of the actions taken to manage the effects of each complexity characteristic, when selecting project team members, is less than 75 points in a scale of 100 points.

It should be noted that whilst conducting the interviews participants were asked and contributed towards:

- The improvement of the 'translation' of complexity characteristics to project management phraseology, as well as
- Considering and adding actions that need to be taken towards managing the effects of each complexity characteristic.

For hypothesis 1 the following five moderating factors – duration, budget, location, type, and procurement method – were considered in order to understand if these influence the sub-process of selecting team members and respondents were asked to identify the level of influence of each moderating factor, using a Likert scale 1 – 5, from 'Very Little' to 'Critical'.

Results

The implementation of the multi-methodology research design was over a period of ten months from May 2007 to February 2008. Apart from the research steps described above it included, two sets of presentations on the aims of the research to the respective heads of the project management divisions, progress reporting during the period of postal questionnaires and presentations to the interviewees.

Postal Questionnaires

The questionnaire was issued to 180 randomly selected project management professionals from within the two strata and 91 valid responses were returned (51%) of which 57% were from the client strata and 43% from the contractor strata. The sample of respondents represented 32% and 8% of the Client and Contractor project management populations within their organizations respectively.

Responses were entered in SPSS (v15) and descriptive as well as inferential statistics methods were used for the analysis of data selecting a significance level of 95% in order to minimize further the sampling error. As the postal questionnaire data were basically ordinal or nominal and associations were sought between one dependent variable and more than two independent variables the parametric technique used was that of Chi^2. The Chi^2 test was used to test for sub-hypotheses 1.1, 1.2 and 1.3 and increase the validity of the arguments. From the responses received 7% were at Director level, 37% at Senior PM level, 46% at PM level, 7% at Assistant PM level and 3% at Site Manager level.

In order to establish the level of current understanding of the project environment prevailing conditions respondents were asked to indicate, in a Likert scale 1 – 5, statements to which they agreed the most or the least. The results in terms of percent response were as follows:

- More to most Static: 22% - More to most Dynamic: 64%,
- More to most Simple: 17% - More to most Complex: 50%,
- More to most Friendly: 49% - More to most Hostile: 16%.

Results regarding levels of awareness, guidance given and implementation of techniques of personal profiling for selecting team members are summarized and presented in Table 1.

Table 1

Response regarding levels of awareness, guidance and implementation of personal profiling techniques for selecting team members

Question	Results	
	Response	**Percent**
2q2: Are you aware of any known techniques/methods of personal profiling?	Yes	71
2q1: Does your organization offer you guidance in selecting project team members?	Yes	68
2q5: In your company, is personal profiling considered, as part of the selection process, when appointing Project Managers to a project?	Yes	9
2q10: Do the site supervisors use any selection process techniques?	Yes	14
2q4: Please indicate for which project team members personal profiling has been carried out, within your company.	None / No	73
2q11: Indicate which of the following techniques/methods your supervisors use/consider for selecting team members	None	78

It should be noted that the majority of responses to question 2q2 indicated that the known techniques were those of Belbin and Myers Briggs. Respondents were also asked to identify, using a Likert scale 1 – 5 - from very little to critical, the current criteria used for selecting team members from PMs to project team members. The results are shown in Table 2 as a percent of response.

In terms of the moderating factors, results indicated that these are considered either critical or very important in terms of influencing the selection of team members sub-process (Antoniadis, 2009).

Table 2

Response regarding the importance of criteria for selecting the project manager and the project team members (in % of responses)

	Criteria for Selection of Project Manager						**Criteria for Selection of Project Team Members**				
Criteria	VL	L	I	VI	C		VL	L	I	VI	C
Availability	3	8	36	36	17		2	5	40	32	21
Capability	1	3	20	53	23		2	1	20	60	17
Technical Skills	1	13	50	33	3		2	4	34	48	12
Management Skills	1	3	36	52	8						
Leadership Skills	1	9	30	43	17						
Experience	1	4	45	33	17		2	3	49	38	8
Previous Performance	1	14	41	35	9		4	10	46	32	8
Project Environment	2	28	50	16	4		10	23	48	18	1
Personal Development	23	42	28	7	0		27	39	30	4	0
Personal Profile	45	31	21	3	0		53	28	18	1	0
Note: VL = Very Little, L = Little, I = Important, VI = Very Important, C = Critical											

Interviews

Two part interviews were conducted with 31 practitioners. The first part consisted of questions regarding perception of complexity within their organization and actions taken. The second part involved the explanation of complexity characteristics, their application in project management and particularly the selection of team members, and the implementation of actions which will indicate management of complexity as this can be generated if its characteristics are not considered. The group of interviewees included from Project Directors (4) to Site Managers (3), with the majority been at the level of Project Manager (10).

In response to the question if their organizations give a definition of complexity 90% of the interviewees indicated that no definition exists. Also 58% indicated that no tools or techniques are used to identify complexity. From those that responded positively 62% indicated that risk management is used as a tool to identify complexity, with the remainder saying programmes (as in planning) and grouping of projects where some of the techniques used.
Figures 1 and 2 indicate, respectively, interviewees' responses regarding 'how complexity is identified in their organizations' and which factors they consider as source of complexity.

For the second part – the complexity characteristics - and as mentioned above, the interviewee response represents the level by which current project management measures taken cover the level of actions required to manage the effect of the corresponding complexity characteristic for the sub-process of selecting team members. Figure 3 provides an overall indication of the average weighted effectiveness of the actions taken to manage the effect of each complexity characteristic when selecting team members. For example for 'autonomous agents' (Table 1) the

overall average of actions taken covers only 16 points of the required level of actions / activities which will ensure the achievement of 100 points for managing the characteristic of autonomous agents.

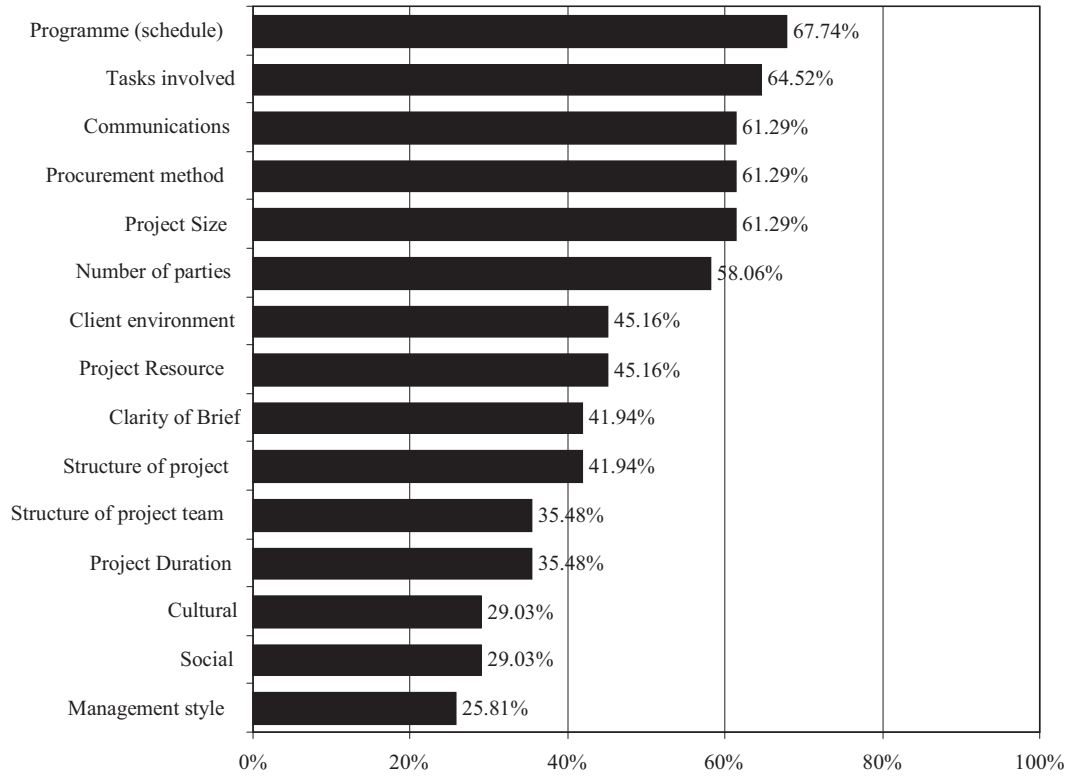

Figure 1: Percent Response Regarding the Identification of Complexity in Projects.

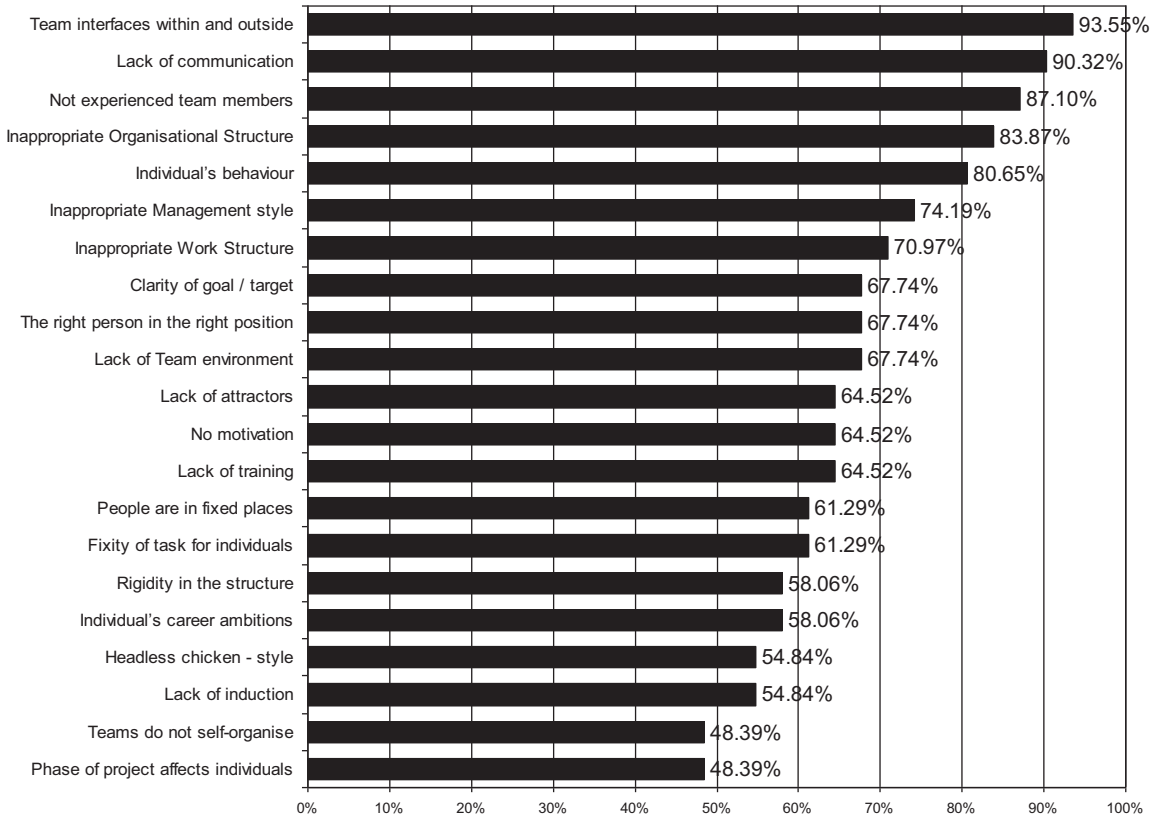

Figure 2: Factors Identified as a Source of Complexity.

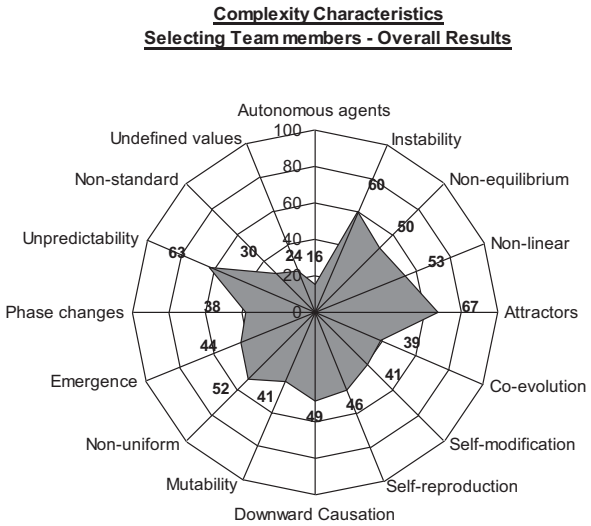

Figure 3: Average Weighted Effectiveness of Actions for Managing Complexity Characteristics.

It should be noted that all proposed actions for all the characteristics were reviewed with the interviewees and any additional actions were included in the listings and considered in the overall weighting.

Analysis

The responses regarding prevailing conditions at the time the research was conducted confirmed the commonly accepted changes that have occurred in construction for the last decade as a response to the Latham (1994) and Egan (1998) reports. That is, an environment which is becoming more friendly, due to different contractual arrangements, but one which remains dynamic and complex.

Postal Questionnaires

The significance of these responses, in terms of the consequences to the selection of team members, is that despite the change to a more friendly environment, awareness (71%) of and guidance given (68%) on personnel profiling this is not considered when selecting PMs (91%) nor any other team members (86%), as shown in Table 2. In particular, 73% of the respondents indicated that personal profiling is not carried out at all for any project team member and 78% indicated that no techniques are used for the lowest project team level by supervisors. This is despite the fact that in one of the participating organizations the internal project management process indicates that Belbin or Myers Briggs should be used when selecting the project team members. The results obtained are triangulated by very recent literature (Keegan and Turner, 2003) and also confirm Green's (2006) conclusion.

Standard, subjective criteria (Ogunlana et al. 2002) continue to be used when appointing PMs, as shown in Table 2, and in a descending order of percentage - Capability, Management skills, Leadership skills, and Availability were considered 'very important'/'critical', with Personal profiling and Personal development not considered. For all the other project team members (Table 3), respondents indicated that the highest criteria for selection were, again in a descending order of percentage, Capability and Technical skills as very important, with again Personal profiling and Personal development not considered.

From the statistical analysis for testing sub-hypotheses 1.1 to 1.3 the following was established:

- Performing a Chi^2 test between 2q1 and 2q5 (Table 3) the value of 'p' was 0.124 much greater than 0.05, which indicates that the null hypothesis cannot be rejected therefore the results are not statistically significant to accept hypothesis H1.1. Thus although guidance is given personal profiling techniques are not used for selecting the PMs.
- Performing a Chi^2 test between 2q1 and 2q11 (Table 4) the value of 'p' was 0.55 much greater than 0.05, which indicates that the null hypothesis cannot be rejected therefore the results are not statistically significant to accept hypothesis H1.2. Thus although guidance is given personal profiling techniques are not used for selecting site team members.
- Performing a Chi^2 test between 1q1 and 2q13 (Table 5) the value of 'p' was 0.602 much greater than 0.05, which indicates that the null hypothesis cannot be rejected therefore the results are not statistically significant to accept hypothesis H1.3. Thus there is no difference in the implementation of personal profiling techniques between client and contractor PMs.

Table 3

Crosstabs – chi² results for testing of sub-hypothesis 1.1

2q5 * 2q1 Cross tabulation			2q1		
			Yes	**No**	**Total**
2q5	Yes	Count	8	0	8
		% of Total	8.9%	.0%	8.9%
	No	Count	40	22	62
		% of Total	44.4%	24.4%	68.9%
	Don't Know	Count	14	6	20
		% of Total	15.6%	6.7%	22.2%
Total		Count	62	28	90
		% of Total	68.9%	31.1%	100.0%

Chi-Square Test	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4.178(a)	2	.124

1 cell (16.7%) has expected count less than 5. The minimum expected count is 2.49.

Table 4

Crosstabs – chi² results for testing of sub-hypothesis 1.2

2q11 * 2q1 Cross tabulation			2q1		
			Yes	**No**	**Total**
2q11	Interview, Agency Interview, Recommendation	Count	14	4	18
		% of Total	15.4%	4.4%	19.8%
	None / No	Count	47	24	71
		% of Total	51.6%	26.4%	78.0%
	Interview & Profiling	Count	1	1	2
		% of Total	1.1%	1.1%	2.2%
Total		Count	62	29	91
		% of Total	68.1%	31.9%	100.0%

Chi-Square Test	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.197(a)	2	.550

2 cells (33.3%) have expected count less than 5. The minimum expected count is .64.

Thus, despite the fact that techniques supporting the selection of team members are available and although it is accepted that the project environment is more complex and dynamic, these formal techniques are not used. Also, despite awareness and guidance given, project management practitioners from both sides – client and contractor, theory is not converted into practice and routine team selection criteria are used and even these are only used down to the level of Team Leader (Table 4).

Table 5

Crosstabs – chi² results for testing of sub-hypothesis 1.3

1q1 * 2q13 Cross tabulation 2q13: Indicate to what organizational level did you, or others on your behalf, carry out personal profiling			**2q13**			
			Discipline & Team Leaders	**Supervisors & Team Members**	**None**	**Total**
1q1	Client	Count	25	20	7	52
		Exp. Count	26.9	19.4	5.7	52.0
		% of Total	27.5%	22.0%	7.7%	57.1%
	Contractor	Count	22	14	3	39
		Exp. Count	20.1	14.6	4.3	39.0
		% of Total	24.2%	15.4%	3.3%	42.9%
Total		Count	47	34	10	91
		Exp. Count	47.0	34.0	10.0	91.0
		% of Total	51.6%	37.4%	11.0%	100.0%

Chi-Square Test	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.014(a)	2	.602

Only 1 cell (16.7%) has expected count less than 5. The minimum expected count is 4.29.

In terms of the effect of the moderating factors responses indicated that only those of project type and budget are slightly considered to influence the sub-process. This indicates that the transactional and technical character of the industry has a small effect on the sub-process, however, not to a critical level.

Interviews

From the general complexity part, the interview responses, and from the details in Figure 1 - responses to the questions '*How does your organization identify complexity in projects*' - it is obvious that mechanistic sub-processes, for example, programme (68%), tasks involved (technical) (65%) and project size and procurement method (61%), are considered as the main identifiers of complexity. Social/soft factors such as the project resource (people), team structure, culture, and the management style are considered as very low in the reasons for identifying complexity. However, the relatively high response towards the two non-mechanistic reasons - communications (61%) and number of parties (58%), indicates that there is a shift towards identifying complexity caused by the number of interconnections / interfaces.

When the interviewees were asked about '*factors/sources of complexity which originate from the project organization*' (Figure 2), emphasis shifted from the mechanistic to the behavioral causes and apart from communication (90%), team interfaces (94%), inappropriate structure (84%) and individuals' behavior (81%) are noticeable in terms of frequency of response. From the results it is also noticeable that there is a distinct difference of view between individuals and companies views regarding the management style. Although companies do not identify that complexity could be arising from management style (26% see Figure 1) the majority of interviewees (74%)

indicated that source of complexity could be the management style followed. This actually can be explained by how individuals' perception could be different to those of their organizations. Other factors, identified by a significant number of respondents, include (Figure 2), technical competence (87%), lack of team environment (68%), if the right person is not in the right position (68%) and even people being in fixed places (61%). Also 65% of interviewees identified lack of motivation and lack of 'attractors' (Table 1) as having a significant impact and causing complexity.

With regard to taking appropriate actions to manage the effects of complexity through its characteristics, from within the selection of team member sub-process, interviewees (Figure 3) indicated that very little is done and that no consideration is given to using any techniques. In particular the characteristics of autonomous agents (16%), undefined values (24%) and non-standard (30%) have received very little management actions, whereas those of attractors (67%), unpredictability (63%) and instability (60%) had some actions taken which could be considered as partly managing the effects of complexity.

The results on the average weighted effectiveness of the current level of actions taken for each complexity characteristic indicate that none has reached the 75 points level of acceptance and thus hypothesis 2.1 is refuted. Therefore hypothesis 2 cannot be accepted indicating that complexity characteristics are not considered when selecting project team members.

Discussion

The results confirm earlier findings and provide statistical confirmation that practitioners of project management and of different levels and sides – client and contractor, in the UK construction industry, do not implement the process of selecting team members and its supporting techniques. Practitioners are aware and guidance is given in using personal profiling and other team member selection techniques, however these are not used. Therefore the importance, influence and criticality of the individual as a team member, are not considered and as such the relationships, behaviors, and boundaries formed when coming together to deliver a project, are neglected.

It is important that, as soft criteria become more prominent in the procurement process, both sides of the project – client and contractor, should focus on techniques beyond simple team building exercises and enable practitioners to practice what they are trained on. Selection of team members should become more prominent and does not have to start just before a project commences. It could be considered as part of the recruitment process with individuals' personal profile being generated from his/her early days in the company. From the individual's side, and in order to alleviate their fears, personal profiles should not become reasons for exclusion but rather as reasons for training and improving skills.

The findings also confirm the gulf that exists between theory and practice or the theory-to-practice transformation. This becomes even more profound when one considers that the general view is that the current environment is friendlier.

Considering the evanescent nature of projects and the interconnections established when individuals come together to form teams, it is obvious that these will cause complexity, however this is not taken into account by the industry.

This is confirmed by the interview results which indicated that complexity is not defined and no tools are used that will enable the management of the effects of complexity. Individuals and companies, as shown in Figures 1 and 2, have a different perception of identification / sources of complexity. The former apportion more weight to soft issues whereas companies concentrate more on the 'harder'/control processes, with the exception of communications. This could be considered as conflicting, since it is the individuals that make up the companies, however, it enforces the fact that companies concentrate on the control processes and have not yet managed to identify 'actions/activities' with which they can address the soft issues. In terms of actions taken to manage the effects of the characteristics of complexity, as discussed and agreed with/by the interviewees, it is profound that not enough actions are taken to enable the management of the effects of complexity. Nonetheless, it was encouraging that interviewees gave positive feedback to using the complexity characteristics as a tool to manage its effects.

It is evident that, in terms of selecting team members, simple activities that will enable the management of the effects of complexity of interconnections are not channeled through to the management of projects. Therefore the potential exists where, by defining and understanding complexity of interconnections and its characteristics and implementing existing techniques, a framework can be developed with which to manage the effects of complexity for the sub-process investigated.

Proposal

Complexity theory acknowledges the failure to comprehend the whole through an understanding of the individual, and instead it endeavors to understand the whole through the interaction of its parts. Therefore, and since interconnections exist everywhere in social, cultural, technical, behavioral and other inter-relationships, we need to consider carefully complexity of interconnections in projects. Relationships were also established, earlier, between projects and complex adaptive systems, in terms of how these consist of many relatively independent parts which are highly interconnected and interactive (Breuner 1995) and which are considered under the theory of complexity (Lucas 2000a, Stacey et al. 2002). Therefore, accepting that projects are streams of disturbances (Wild 2001) with incubating pathogens (Busby & Hughes 2004), allows all the parties to understand that they are 'in for a ride', and therefore the project management definition given earlier should be considered.

Plan of Action

Complexity in construction projects, but also more generally, requires a structured approach, the establishment of a simple plan of action and the availability of a framework which will enable practitioners to manage its effects.

The plan of action described in Figure 4 below is based on the simple and extensively implemented cycle of, define, identify/understand, utilize tool/means available, implement actions, monitor/follow up actions and review/improve.

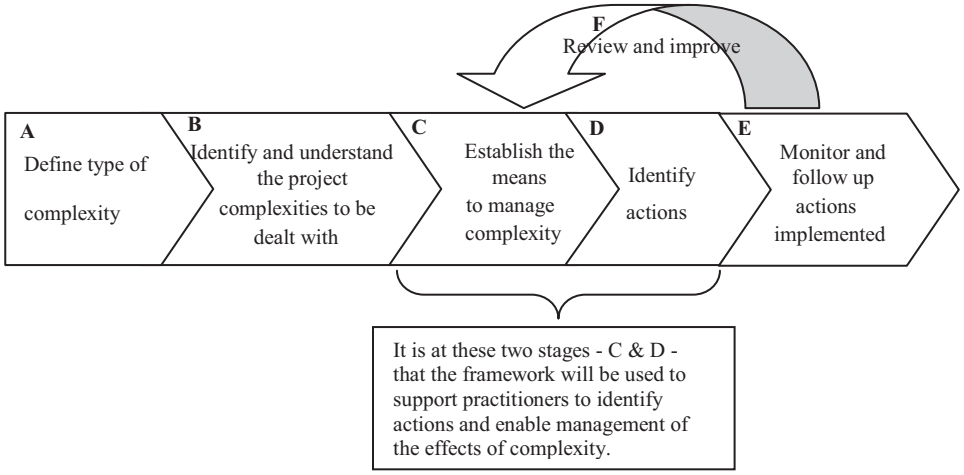

Figure 4: Action Plan for a Structured Approach to Managing Complexity.

With regard to complexity of interconnections and in terms of the tools/means to be used (steps C and D), during the research period the decision matrix process was used to evaluate three options and select the best suitable solution (Antoniadis 2009). The framework developed is a tool that enables the management of the effects of each complexity characteristic through the specific process, in the case of this paper the process of selecting team members. The framework allows Project Managers and Team Leaders:

- To ascertain the level of managing its effects at specific points in time,
- To propose specific actions which will minimize the effects of each complexity characteristic,
- For the actions to be monitored, reviewed and improved, and
- Through its flexibility, implementation at all project levels.

Since it is focused on the process it is not restricted by the type of project and/or the management style(s). The simple and holistic approach offers practitioners an innovative and straight forward handling of the effects of complexity of interconnections on projects through each project management process. As described in Figure 4 deployment of the Framework for Managing Complexity of Interconnection (F4MCI®) occurs during steps C and D. A detailed description of the objective, the scope and how is to be implemented is given in the following sections.

The Framework – F4MCI®

The objective is to enable the Project Manager (PM) and her/his Team Leaders (TLs) to manage the effects of complexity of interconnections on the project through the respective project management processes.

Scope

The scope of the F4MCI® is to measure the effect current actions have on the management of complexity, through its characteristics, and prompt the PM and TLs to consider, through its reporting mechanism, further actions that will enable the management of the effect of each characteristic for the benefit of the project.

The How

Each complexity characteristic has been translated into project management phraseology and against each one a set of questions and actions have been established and validated by project management professionals. As the PM and TLs respond to each question the F4MCI® measures and records the effect of the actions taken. Reports produced, together with the questions/actions, prompt the PM and TLs to consider and implement further actions that will enable them to manage complexity. The F4MCI® also enables them to establish a short term/continuous improvement plan.

What is the F4MCI®

The F4MCI® is part of a wider set of simple software tools that deal with complexity of interconnections for each one of the project management sub-processes which are used to measure the project management outcome. These sub-processes are (Collins & Baccarini 2004):

a) Selecting project team members
b) Nanaging the team (the style adopted)
c) Effective use of resources
d) Conflict management
e) Structuring the project team
f) Monitoring and control
g) Reporting

Who and When Should Use the F4MCI®

The F4MCI® software is used by the PM of the project and all the TLs of the teams that will participate in the delivery of the project and at the very early stages, within four to six weeks and as and when teams are formed.

How is the F4MCI® Used

The user(s) (PM/TLs) go through each characteristic and are required to respond to questions by indicating (ticking of boxes) the actions taken that will enable the management of the effects of the characteristic. Each question has a weighted measure for managing the effects of the characteristic and the users' selection(s) are evaluated. For a number of responses and for reporting purposes, the user(s) is required to indicate the reason for making the respective selection. As the user(s) progress through the 16 characteristics all the responses are gathered and recorded. At the end of each 'run' the software produces a graphical as well as a tabular report indicating the average weighted level of managing the effects of each complexity characteristic. The execution/run of the F4MCI® is performed at certain frequency and within a certain period. The intervals between successive 'runs' of the tool are used by the PM/TLs to implement the actions identified / required and also to resolve issues, as required, with management.

What is the Output and How is to be Used

The F4MCI® outputs/reports, when the execution is completed, are a radar graph indicating the average weighted level of managing the effects of each complexity characteristic, and a report which indicates if the level achieved is acceptable. A sample of the radar graph and the report are shown in Appendix 2, Figures 5 and 6. An additional report which is generated from all the comments made, regarding '*reasons for taking respective actions*', is used as a feedback mechanism. All three reports produced enable the user(s) to review and discuss actions required to be taken in order to improve the response/management of the each characteristic and therefore complexity of interconnections.

Conclusion

Literature review and the results obtained indicate that in construction industry project practitioners, from both sides - client and contractor, do not use any techniques for the selection of team members and therefore there is need for an alternate / higher initiative that will improve the process. Also, as generally accepted and shown from the results, the construction environment is more complex and dynamic. However, neither tools are available to practitioners, nor consideration is given to complexity and its characteristics when selecting team members. In fact determination and management of complexity remains within various mechanistic tools which have been established within the construction industry.

Since the mid-90s, the Latham and Egan reports, a number of drivers have been suggested and are known, however, as shown by the results these recommendations have produced very few results in terms of selecting team members. Although techniques for personnel profiling have found their way into company processes very few actions are implemented and even fewer have influenced / affected this soft side of the project management processes.

Having linked the complexity characteristics to project management it is of interest to all parties to implement actions that will minimize or maximize the effects of complexity on the numerous project management sub-processes. Thus, considering the sub-process of selection of team

members under the complexity perspective and implementing the proposed framework and the established actions it will allow for the management of complexity. At the same time it can be proven a much more plausible carrot / encouragement for project management practitioners to implement the process.

In a friendlier and more dynamic environment, where both clients and contractors allow for a more open and extended front end project period, selecting the appropriate PM and team members based on already established profiling techniques is feasible and achievable. Additionally in a complex environment the implementation of actions identified through the framework developed (F4MCI®), for the selection of team members process, and understanding complexity and its characteristics will enable the management of its effects.

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Appendix 1

Table 6

Complexity characteristics and relevance to construction (Lucas 2000b)

Group	Characteristics	Lucas' description of characteristic and authors' adaptation relevant to construction
Conditiona l	Autonomous agents	*Complex systems are generally composed of independent or autonomous agents (not the identical parts often assumed in science). All of these agents are regarded as equally valuable in the operation of the system*

		Each and every individual and group / company contributing to a project is considered to be an autonomous agent and regarded as equally valuable in the operation of the system.
	Instability	*Over the long term stepped evolution or catastrophes will exist (similar to punctuated equilibria). Sudden swaps between attractors become possible as the system parameters approach the boundaries of the attractors*
		Stepped evolution(s) or catastrophes do occur in projects. Attractors appear (currently unintentionally) and become system parameters, which will attract other team members and avoid chaotic behavior of the project system.
	Non-equilibrium	*Energy flows will drive the system away from an equilibrium position and establish semi-stable modes as dynamic attractors*
		The various 'pulls', contractual, behavioral, stakeholder influences, company politics, and management pressures, to mention but a few that occur in projects from the multiple contributors which, depending on the situation, will establish semi-stable modes with 'players' (attractors) who will attempt to influence the project at the opportune moment.
	Non-linear	*Complex system outputs are not proportional to their inputs*
		Individuals seen as complex systems that work in a project and outperform themselves when faced with challenging conditions and under a good environment encouraging team work, understanding and noticing individuals' contribution, establishing team work rather than group work or individualistic behavior.
	Attractors	*Self-organization relates to the presence in the system of dynamical attractors*
		Simple systems (individuals) come together and many times self-organize to form more complex systems which are pulled by the presence of the dynamic attractors of the moment. So we have individuals that could easily not be the line managers, who because of their capabilities, abilities, and behavioral attributes become 'attractors'.
Developmental	Co-evolution	*The parts are regarded as evolving in conjunction with each other in order to fit into a wider system environment*
		This is self-evident in the Project Management world. Individuals within teams and teams within projects co-evolve and initially attempt to understand each other in order to understand the requirements and fit into the wider project environment

	Self-modification	*Parts can change their associations or connectivity freely - either randomly or by evolved learning procedures*
		Individuals and teams form and change their associations as they are evolving and learning during the project life-cycle. As new teams enter the project environment new associations are created between individuals and teams. Managing and coordinating the self-modification of individuals and teams to the benefit of the project, through learning, will improve the project outcome.
Developmental	Self-reproduction	*Usually these systems have an ability to clone identical or edited copies*
		The structure is set up to be the same throughout the project – cloned / copied, despite the fact that different teams may require different organizational structure or style of management.
	Downward Causation	*The existence and properties of the parts themselves are affected by the emergent properties … of the whole*
		The existence and skills (including characteristics) of individuals and teams within the project are affected by higher level systemic features of the whole. A number of structures that are set up at project level that indicate the systemic features of the project affect the existence, the properties / requirements of the project parts themselves.
	Mutability	*Random internal changes (mutations) or innovations typically occur in these systems.*
		It is typical of random mutations to occur in Projects. Project Management has to identify and manage them. Considering the 'individual' as a system, it is highly likely that random internal changes will occur during the life cycle of the project and these will have an effect on the project through the individual's performance. These internal changes could be beneficial or detrimental and could be caused by either internal, to the project, reasons (e.g. team members' behaviors), or the individual's employer (e.g. promotion or demotion), or personal.
	Non-uniform	*Each part evolves separately, giving a diversity in rule or task space*
		The individual parties evolve separately and give diversity in projects. This again has to be identified and managed rather than controlled and stopped. Each person brings its own attributes to the project at the level it operates. Diversity improves the outcome, as the individual(s) are attempting to achieve a higher status, or benefit.
	Emergence	*The properties of the overall system will be expected to contain functions that do not exist at part level*

		Emergence describes the power of the whole delivering a lot more than the individual parties to the project. The usual 2+2=5. The project takes from each part and combines all properties to produce a holistic system that will deliver the project.
	Phase changes	*Feedback processes lead to phase changes, sudden jumps in system properties*
		As far as the project and the individuals are concerned this characteristic highlights the importance of feedback processes. Phase changes / sudden jumps, depending on the approach taken, could have a detrimental or beneficial influence in the individuals' attributes. These could either be the standard project phase / stage changes that are based on feedback to higher management levels, or even within the standard PM processes that could lead to the sudden jumps described by this property.
Behavioral	Unpredictability	*In such interacting systems a chaotic sensitivity to initial conditions can occur*
		It represents the importance of the initial project conditions which if not managed appropriately could lead to chaotic conditions occurring later on.
	Non-standard	*... initially homogenous systems will develop self-organizing structures dynamically*
		Each system that comes to the project will self-organize dynamically with the other project systems and change from its initial homogeneous status. Complexity requires for systems to have the characteristic of 'non-standard' in order to be able to evolve from homogenous systems into dynamic self-organized ones.
Behavioral	Undefined values	*The meaning of the system's interface with the environment is not initially specified and this must evolve*
		Identifying the system's/project's interfaces with the environment as the external stakeholders this characteristic advocates the need for the evolution of the interfaces as the project progresses. In terms of selecting the team members, and for several roles within the team, the influencing factor of the project interfaces should be identified and introduced in the selection criteria process.
Note: Lucas' (2000b) description of complexity characteristics are shown in italic.		

Appendix 2 - F4MCI® Reports from Running the Selection of Team Member Module

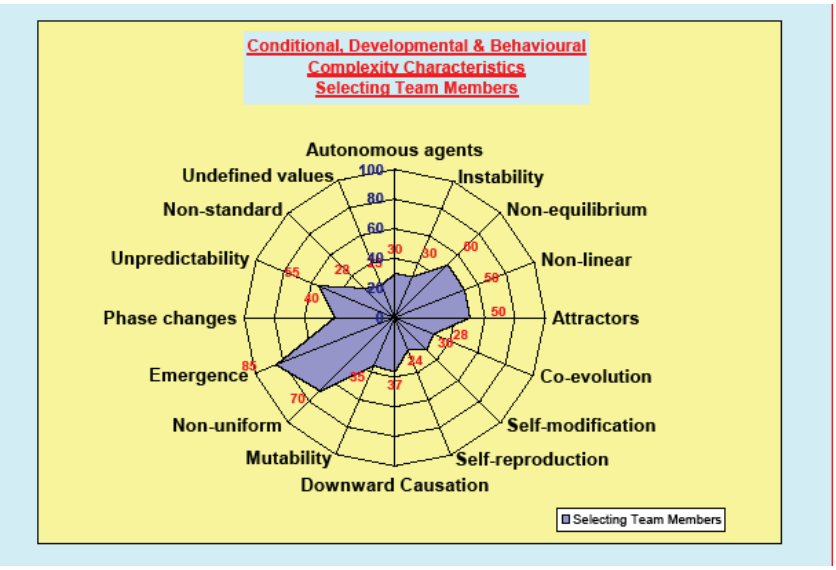

Figure 5: Radar Graph Report from F4MCI® for Selecting Team Members.

Selecting Team Members		
Characteristic	Score	Comment on management of complexity characteristic
Autonomous agents	30	is not managed, more actions required
Instability	30	is not managed, more actions required
Non-equilibrium	50	is not managed, more actions required
Non-linear	50	is not managed, more actions required
Attractors	50	is not managed, more actions required
Co-evolution	28	is not managed, more actions required
Self-modification	30	is not managed, more actions required
Self-reproduction	24	is not managed, more actions required
Downward Causation	37	is not managed, more actions required
Mutability	35	is not managed, more actions required
Non-uniform	70	is not managed, more actions required
Emergence	85	is managed, some more actions are required
Phase changes	40	is not managed, more actions required
Unpredictability	55	is not managed, more actions required
Non-standard	28	is not managed, more actions required
Undefined values	23	is not managed, more actions required

Figure 6: Report from F4MCI® for Selecting Team Members.