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Quality Management in Computing Services - A study to Determine the Current State of Quality Management Practices of Computing Services in New Zealand's Industries

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QUALITY MANAGEMENT IN COMPUTING SERVICES

A study to determine the current state of quality management practices of computing services in New Zealand's industries.

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This paper reports the results of an empirical investigation into the general perception of quality management practices, the direction the New Zealand industry is taking in quality management and the current status of quality management practices in computing services of organisations and companies.

The results of the study indicated that a large percentage of companies were interested in quality management practices. A majority of the companies surveyed were "aware of the need for quality", and had begun "planning" for it. There may be a shortage of personnel and knowledge in the quality subject areas. However, the interest and willingness to work on quality improvements were encouraging.

1. INTRODUCTION

Information systems and information technologies (IS/IT) are playing an ever increasing role in the management of all types of industry. Ultimately their usefulness and viability depend upon the quality of their performance, that is their ability to satisfy the needs of customers of the systems.

Achieving "quality performance" will not only provide a system that is far more likely to meet the customer's needs first time, it will also be more likely to gain a competitive commercial advantage for the organisation. Without "quality performance", the supplier and purchaser will spend increasing amounts of time and money on coping with error-prone and inefficient systems. Consequently, any poorly designed systems will be under-used and unproductive.

In their landmark book 'In Search of Excellence', Peters and Waterman (1984) identify a number of key factors that set the very successful companies of the world apart from the less successful ones. One of those key factors is the commitment to quality evident in the very successful companies.

In recent years, our knowledge of methods to ensure quality has changed. We now know that quality control, quality assurance, quality management and "customer focus" are all essential means of ensuring quality. Adopting the quality management approach should ensure that the processes used in the development and management of computing services are designed with the customers' requirements in mind while at the same time the outputs of IS/IT are serving the needs of other organisational functions.

It is in this context that this research study focused on the use of quality management in the development and management of computing services that provide IS/IT. Quality management provides a framework (for all those methods and procedures) and a systematic approach for computing services to make IS/IT development more successful. It also incorporates the computing service providers into the overall quality system used to implement a company's quality policies.

Research findings indicated that, in spite of national and international efforts to introduce quality management and quality standards to all industries, many organisations and companies show weaknesses in their application, (CSC Index, 1991; Logica Study Team, 1988; Management Consultants, 1988). This is especially so in the area of IS/IT (I/S Analyzer, 1994). There is a general lack of knowledge of the more technical side of modern quality management in industry and commerce, particularly in quality assurance methods and the new standards for quality management. In addition, the use of quality management was not without its problems. Avison (1994) and Bell (1994) found that there were difficulties in:

- interpretation of terms in quality standards (generic differences in hardware/software products),
- interfacing traditional practices (computing services methodologies) with the quality management framework,
- adopting a general standard for specialised purposes,
- the high cost involved in adopting quality management practice, and in
- the suitability of implementations (company size and critical level of the products or services supplied).

These difficulties lead to a concern about the usefulness of quality management practices. It was decided to begin the study with a review of the current status of quality management of computing services in New Zealand organisations and businesses. This is because there appeared to be:

- variable levels of knowledge of quality systems within the New Zealand industry,
- difficulties observed with effective implementation of quality systems, and
- doubts about the general applicability of quality systems to all aspects of computing services.

The primary objective of this study was to gain an understanding of the current state of quality management practices of computing services in New Zealand industries. In particular, the purpose of this research was to gain familiarity and/or achieve new insights into the current situation. The research included identifying the

development of computing services, choosing an empirical measure and performing the empirical measurements of various factors that may affect quality management practices of computing services.

2. THE SURVEY

After reviewing some of the literature and the background studies, it was recognised that the research area was broad and the research study was exploratory in nature. As the objectives were to find out the current status of quality management practices of computing services in New Zealand industry, the survey methodology was regarded as appropriate. The survey consisted of four parts. The first and second part sought information about the respondent's business characteristics and general perception of quality management. The third part was concerned with the customer-supplier relationship in computing services. The questions in the fourth part relate to implementation of quality management features.

In relation to the use of an appropriate quality management measure, several good quality practices were considered. They included standards or guides such as: ISO 9000, NZS 3563, TickIT and CMM. However, background studies indicated that ISO 9000 was suitable to be used as a measure to indicate if good quality management practices were being used or contemplated. It is a recognised standard (nationally and internationally) and it is general enough for use in a multi-disciplinary field such as computing services.

At the end of October 1993, the survey questionnaire was sent to 411 computing services managers of organisations and companies throughout New Zealand. Of the 411 questionnaires sent out, 152 were returned, 5 were found to have been sent to an incorrect address or the company was no longer trading, and 7 respondents declined to complete the survey. One hundred and forty useable replies were received. This represents a response rate of 35%.

3. ANALYSIS

The responses were first analysed to assess whether they were representative of New Zealand industry.

3.1 Regional Spread

Figure 1 shows the regional breakdown of the 140 responses against the selected 411 sites in the mailing list and the New Zealand's 1991 business activities. The categories used were based on the official regional council classification (New Zealand Official Yearbook, 1992).

The respondents were representative of the business population. There were some differences, between the responses to the question and the percentage of business activities in each region, however there are explanations for these.

The Wellington region shows an unusually high response rate. This was not surprising, given that Wellington is a business center, where a number of head offices of companies and government departments are located. It was noted that the proportion of Wellington region representation in the mailing list was also high.

In contrast, Northland, Waikato, Bay of Plenty, Taranaki, Marlborough and Canterbury show significantly lower percentage of responses when compared to the business activities in these regions. They represent locations with relatively less IS/IT intensive industries, therefore, the proportion of respondents would be expected to be smaller.

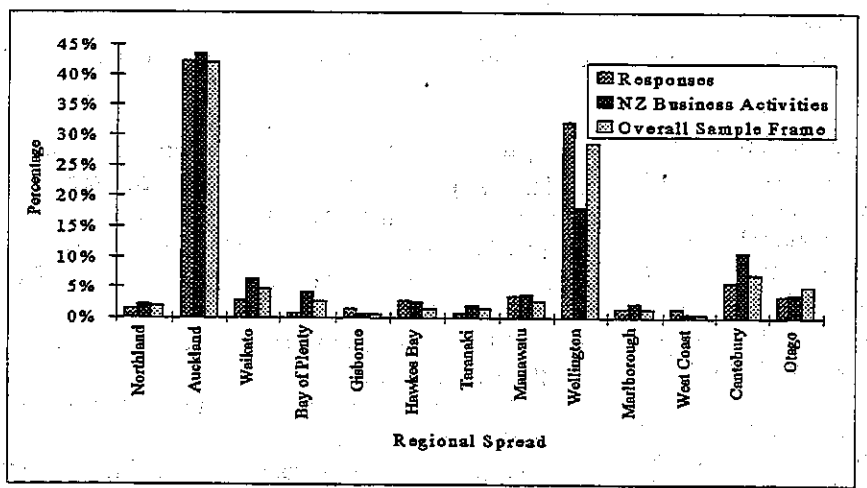

Figure 1: Regional Responses, NZ Business Activities (1991) and Sample Frame Spread.

3.2 Industry Classification

Table 1 and Figure 2 show the New Zealand Standard Industrial Classification (NZSIC) breakdown of the 140 responses against the New Zealand's 1991 business activities.

There were marked differences for industry sectors "Electric, Gas and Steam" and "Construction". However, the results were consistent with other recent surveys and business patterns (New Zealand Official Yearbook, 1992; New Zealand Official Yearbook, 1994; Macdonell, 1994).

The difference in proportion of responses from the "Electric, Gas and Steam" sector, can be accounted for by the recent establishment of electricity and gas distribution/retail authorities. Hence, the percentage measurement for the responses, which was taken in 1993, as compared to the percentage of business activities in 1991 was high. The low response rate for "Construction" was due to the drop in "Construction" business activities between 1991 and 1993 (New Zealand Official Yearbook, 1992; New Zealand Official Yearbook, 1994).

NZSIC Industry Sector	Classification Number	Responses Percentage (Number)	Business Activities
Agriculture, Forestry and Fishing	10000	3% (4)	3.54%
Manufacturing	30000	11% (15)	10.52%
Electricity, Gas and Steam	40000	12% (17)	0.36%
Construction	50000	1% (1)	14.31%
Wholesale and Retail Trade	60000	27% (38)	30.10%
Transport and Communication	70000	6% (9)	7.18%
Business and Financial Services	80000	26% (36)	16.50%
Community and Social Services	90000	14% (20)	17.50%

Table 1: Industry Sector - Responses and NZ Business Activities (1991) Spread

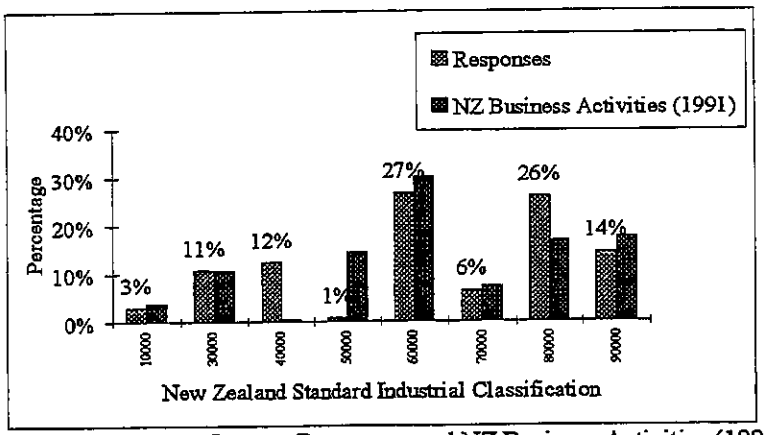

Figure 2: Industry Sector - Responses and NZ Business Activities (1991) Spread

Title		Frequency	%
IS Manager		27	19
Computer Services Manager		13	9
Quality Manager, Analyst, Co-ordinator, Specialist	*	11	8
MIS and EDP Manager		10	7
Manager (management, business, market, customer, services or facilities)	*	9	6
Director (Operations, Computer Services, IT Services)		9	6
Managing Director	*	9	6
IT Manager		8	6
Financial Controller, Accountant, Accounts Manager	*	7	5
General Manager	*	7	5
Consultants		6	4
Manager, (Information Services, Data and Networks)		5	4
Systems Manager		5	4
Company Secretary	*	4	3
Operations/Service Manager	*	4	3
Product Development/Services Manager	*	2	1
Regional Manager	*	2	1
System Analyst/Programmer		2	1
	Total	140	100

Table 2: Frequency of respondent job titles

3.3 Job Titles

The first section of the survey included spaces for the respondent's name, job title, and the name of the company. Of some interest here were the job titles of the respondents, their frequencies are shown in Table 2. Responsibility for computing services would appear to be well defined, with jobs specific to computing or information systems. This takes up the two major classes of 29% (27 + 13) responses - the IS and computer services manager class. Moreover, about 38% of the responses (marked * in Table 2) were from non-computing classes, that is, general managers, operational managers, company secretaries, and directors. This indicates that a good response was received from non-computing positions. There was a high level of responses from senior management, which indicates the importance that companies appear to place on their IS/IT systems.

3.4 Means, Medians and Standard Deviations

The means, medians, and standard deviations were used to describe the central tendencies of all the simple rating scale type of responses. Refer to Table 3 and Figure 3. Figure 3 is a Box-and-Whisker distribution diagram. It provides a visual indication of distribution of the responses to each question (Myrvold, 1990). The plot depicts the spread of values about the mean and median of a distribution. For non-normal data the spread about the median is considered to be a more robust indicator of central location when the underlying data is skewed (Daniel, 1990).

		mean	median	S.D.
General	A1. Personal interest in QM practices	4.39	5	0.86
	A2. Personal involvement in QM practices	3.80	4	1.03
	A3. Personal knowledge in ISO 9000	3.41	3	1.16
	C5. Customers/users level of computer literacy	3.29	3	1.01
	C6. Interaction between developer & user	3.49	4	1.04
	C7. Senior management commitment	4.01	4	1.08
	C8. Staff acceptance	3.62	4	1.01
	C9. Customer satisfaction	3.49	4	0.85
Quality	DI1. Quality policy	2.24	2	1.11
Practices	DI2. Implementing quality policy	2.28	2	1.19
	DI3. QM effectiveness review	2.09	2	1.09
	DII1. Identifying customer requirements	2.51	2	1.23
	DII2. Product/service specification	2.51	2	1.27
	DII3. Specification verification	2.54	2	1.29
	DII4. Contract review	2.16	2	1.15
	DIII1. Design development	2.41	2	1.23
	DIII2. Documentation: design & development	2.48	2	1.19
	DIII3. Change management	2.40	2	1.19
	DIII4. Sub-contracting management	2.01	2	1.08
	DIII5. Purchase management	2.28	2	1.15
	DIV1. Documentation control	2.27	2	1.16
	DIV2. Customer management	2.19	2	1.08
	DIV3. Internal audit	2.25	2	1.22
	DIV4. Staff training	2.31	2	1.16
	DV1. Customers interaction	2.47	2	1.21
	DV2. Marketing	2.02	2	1.08
	DV3. Service delivery	2.11	2	1.06
	DV4. Corrective and preventive action	2.62	3	1.29
	DV5. Customer's assessment	2.34	2	1.22
	DV6. Training needs for customers	2.20	2	1.12
	DV7. Collection and analysis of performance	2.25	2	1.21

Table 3: Mean, Median and Standard Deviation for Rating Scale Responses

The aggregated responses to "personal perception" (A1-3), "customers/users relationships", "management commitment", "staff acceptance" and "customers satisfaction" (C5-9) questions were relatively high. There were up to 75% of responses that were above or equal to level 3 - "medium". However, the aggregates for the quality management practice (DI1-3, DII1-4, DIII1-5, DIV1-4, and DV1-7) were clearly lower (median=2). These responses covered "Aware of need for the quality system feature and planning commenced".

There was a clear indication that respondents were "very interested" (the median) in quality management

practices. However, the "involvement in quality management" and "knowledge of ISO 9000" questions were scored lower and the responses were less homogeneous, although still substantially high overall. The median for "involvement in quality management" was "use them occasionally" and for the "involvement in quality management" was "familiar, but don't use them". These suggest that there is an awareness of the need for quality management practice but that implementation is less than desirable.

The responses from the questions about organisational type, indicated that staff and management were committed to quality management practice in computing services. The median response was "4" for both "Senior management commitment" and "Staff acceptance".

The quality management practices were consistently low (median=2), that is the "Aware of need for the quality system feature and planning commenced" response alternative. The exception was "procedures for corrective and preventive action in response to customers" (DV4), which received higher scores and a wider spread of answers (median=3, "quality system feature partially implemented and documentation in progress").

In summary, the results indicated a "high" level of interest, management commitment and staff acceptance of quality management practices. There were positive signs of "involvement in quality management" and "knowledge of ISO 9000". However, the implementation of quality management system features appears to be lower than is desirable.

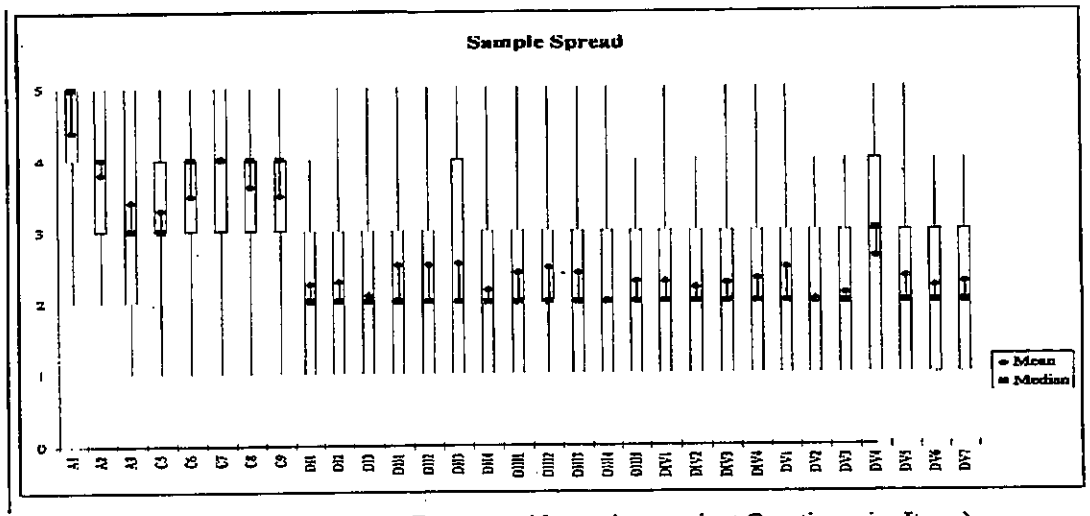

Figure 3: Box-and-Whisker diagram (Response Alternatives against Questionnaire Items)

3.5 "interest", "involvement" and "knowledge of ISO 9000"

"Interest", "involvement", "knowledge of ISO 9000", and "companies working towards certification of a quality standard" were identified to have significant association (H_0 rejected at $\alpha < 0.01$) with good quality management practices.

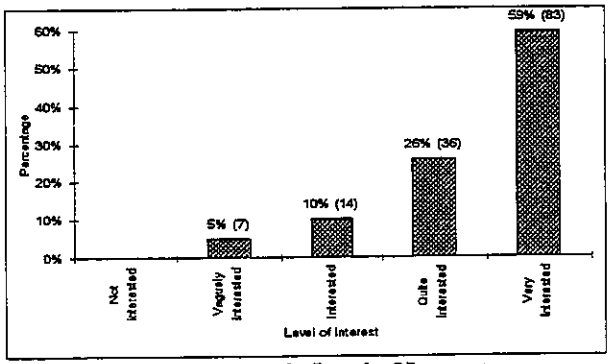

Figure 4: % of Responses in Level of Interest

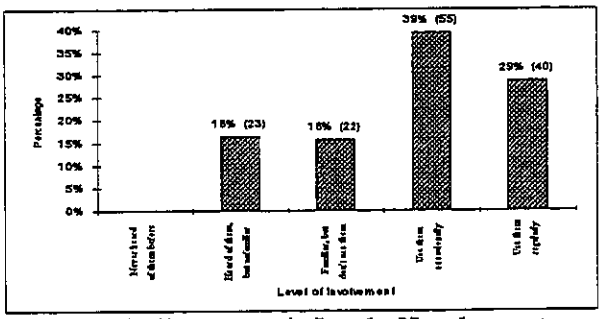

Figure 5: % of Responses in Level of Involvement

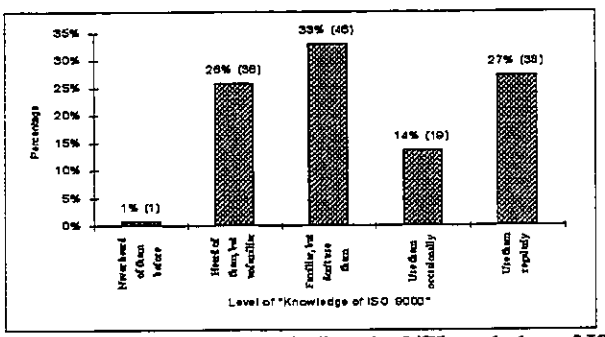

Figure 6: % of Responses in Level of "Knowledge of ISO 9000"

Respondents with a high level of "interest" were those responded with response alternatives of "very interested" and "quite interested". Those of high level of "involvement" or "knowledge of ISO 9000" had response alternatives of "uses them regularly" and "uses them occasionally".

Figure 4, 5 and 6 show the overall breakdown of responses on "interest", "involvement in quality management practice" and "knowledge of ISO 9000". A greater level of interest was evident (the percentage interested to any degree being 95%) than was either the degree of involvement (being 68%) or the level of knowledge of ISO 9000 (41% using their knowledge).

Table 4 and 5 provide a cross-tabulation of "involvement in quality management practice" in relation to "interest" and "knowledge in ISO 9000" respectively.

"involvement in quality management practice"	never heard of them before 0% (0)	heard of them, but unfamiliar 16% (23)	familiar, but don't use them 16% (22)	use them occasionally *39% (55)*	use them regularly *29% (40)*	100% (140)
very interested		6	9	32	36	*59% (83)*
quite interested		5	6	21	4	*26% (36)*
interested		7	6	1		10% (14)
vaguely interested		5	1	1		5% (7)
not interested						0% (0)
"interest in quality management"						

Table 4: "interest" in quality management practices

"involvement in quality management practice"	never heard of them before 0% (0)	heard of them, but unfamiliar 16% (23)	familiar, but don't use them 16% (22)	use them occasionally *39% (55)*	use them regularly *29% (40)*	100% (140)
use them regularly			1	8	29	*27% (38)*
use them occasionally				15	4	*13% (19)*
familiar, but don't use them		1	17	25	3	33% (46)
heard of them, but unfamiliar		22	4	6	4	26% (36)
never heard of them before				1		1% (1)
"knowledge of ISO 9000"						

Table 5: "involvement in quality management practices" and "knowledge of ISO 9000"

Of the 68% (29% + 39%) of respondents that used quality management practice, at least some of the time, 93 (32 + 36 + 21 + 4) or 98 % ($\frac{93}{95}\times 100$) were at least quite interested in it.

Of those 68% of respondents using quality management practice, 56 (8 + 29 + 15 + 4) or 59% ($\frac{56}{95}\times 100$) used the ISO 9000 standards. In other words, of the 68% of respondents using quality management, but not ISO 9000, 39 (25 + 3 + 6 + 4 + 1) or 41% used TQM, CI, NZS 3563 and others.

Over the entire sample, 40% (27% + 13%) used ISO 9000 standard while 28% (68% - 40%) used other quality management practices. Overall then, 32% used no practices, 40% used ISO 9000 and the remaining 28% used other quality management practices. The largest single group (Out of those using ISO 9000, other practices or none at all) was the ISO 9000 group.

3.6 Certification to a Quality Standard

The survey indicated that 15 (4 + 6 + 5) or 11% ($\frac{15}{140}\times 100$) of organisations or companies had at least one of their systems or sub-systems certified to a standard (Refer to Table 6). Of that 11%, 33% ($\frac{5}{15}\times 100$) had certification for computing services systems. Hence, of the 135 organisations or companies (excluding those 5 respondents who already had their computing services registered), 47% ($\frac{64}{135}\times 100$) were working towards certification to a standard for their computing services. Of that 47% of organisations or companies, only 9.4% ($\frac{6}{64}\times 100$) had other sub-systems certified to a standard.

		"companies had at least one of their system or sub-system certified to a standard"			
		Yes (15)		No (125)	
"computing services system certified to a standard"	No (135)	4	6	58	67
	Yes (5)	5	-	-	-
		(9)	Yes (64)		No (67)
			"working towards certification to a standard for their computing services"		

Table 6: Certification to a Standard

There was a large number (67 or 50%) of organisations and companies that were not "working towards certification to a quality standard for their computing services". However, the study was unable to conclude whether the organisations and companies had the intention in short-term or long-term to "work towards certification to a quality standard for their computing services".

Of those companies, who had at least one system or sub-system certified to a standard, or, those working towards certification to a standard for their computing services, the ISO 9000 series standard was the most commonly used. There were organisations and companies working towards their own companies' internal standards, for example, Total Quality Management (TQM) or Continuous Improvement (CI) programme. A small percentage of respondents were working on such standards as: FORD 101, CAA rules, NZS 3563, ISRS and State Service standards. Some companies were working towards the New Zealand National Quality Award, or the Malcolmn Baldrige Award. Other than the ISO 9000 quality system standard, no other systems were considered to have a significant number of users.

χ^2 tests were used to compare the frequency distribution of the various responses. The criterion, "companies working towards certification of a quality standard for their computing services", was identified to be one of the key factors in the χ^2 tests (H_0 rejected at $\alpha < 0.01$). As expected, these companies were found to have significantly achieved higher level of quality management practice than companies that were not "working towards certification". Of those "working towards certification of a quality standard", an average of 61% achieved level 3 and above. That is, respondents had "quality system feature partially implemented and documentation in progress".

3.7 Relationship with Customers

In order to have an overview of the responses, it was possible to determine whether the computer services were internally or externally oriented. The questions about the "total number of internal customers", "total number of external customers", and percentage of the company's product or services being exported were considered. The results showed 39% (21% + 18%) of the respondents to be externally oriented. Table 7 describes these findings further.

With reference to Table 7, there were 25% (35) of the respondents that were in the IS/IT business or were "IT organisations". The percentage of respondents exporting their product or services overseas was 35% (49).

Tables 8 and 9 show the percentage breakdown of "who initially identifies new requirements" and "who specifies technical requirements" for computing services, categorised by the type of customers being served (whether internal or external).

	All Responses	Exported	IS/IT Organisations
Internal	61% (86)	19% (26)	1% (2)
External	21% (29)	9% (13)	15% (20)
Both	18 % (25)	7% (10)	9% (13)
	100% (140)	35% (49)	25% (35)

Table 7: Internal, External, or Both (Internal and External) Oriented Respondents

	Developers	Customers	Both	NA	
Internal Customer	6% (8)	*52% (73)*	29% (41)	13% (18)	100% (140)
External Customer	12% (17)	31% (43)	13% (18)	*44% (62)*	100% (140)

Table 8: Proportion in % (number) on "who identifies new computer product or service"

	Developers	Customers	Both	NA	
Internal Customer	*53% (74)*	24% (33)	14% (20)	9% (13)	100% (140)
External Customer	29% (41)	19% (27)	8% (11)	*44% (61)*	100% (140)

Table 9: Proportion in % (number) on "who specifies the technical requirements of product or service"

The percentage responding Not Applicable (NA) was the same (44%) for the externals for both questions. It means that where customers were external, whether developer or customer identifies or specifies the new or technical computing requirements, was more difficult to determine. In the case of the internal customer the greater percentage (52%) reported to identify new product or services were the customers, followed by both customers and developers (29%) in contrast to only 6% of the developers. However, in the case of specifying the technical requirements of the product or services the greatest percentage (53%) reported this to be the domain of the developers, with a smaller percentage (24%) being the domain of the customers and task was shared between them less (14%).

This suggests that for internal customers, it is the customers that identify new products, but the technical specification is written by the computer specialist. The same pattern of responses emerged for the external customers but to a lesser extent.

The data indicated that the majority of respondents provide services to internal customers. It may be considered that the quality control for internal services would be less than for organisations competing fully in the market place. Other studies have shown that there was little awareness amongst internal oriented providers of quality management (Logical Study Team, 1988).

The χ^2 tests show that, "IT organisations" and "external oriented companies" were positively associated with the responses on "customers' level of computer literacy" (with p values = 0.004 and 0.003 respectively, H_0 rejected at $\alpha < 0.01$, $df = 4$). However, it should be noted that most IT organisations were "externally oriented" (and expected to be). In an "externally oriented" environment, it would be normal for customers to request the product or services. Hence, it was not unusual to have considered customers of an "externally oriented" environment or "IT organisations" to have a "high level of computer literacy".

The χ^2 tests show that when the respondents were "both - internally and externally oriented", there were positive association with responses on "knowledge of ISO 9000", "formal procedure for reviewing quality management effectiveness" and "procdures for marketing product or services to current and potential customers". The p values were 0.005, 0.001 and 0.007 respectively. The H_0 was rejected at $\alpha < 0.01$ and $df = 4$.

When respondents had both developer and customer to "identify product or service for external customer" or "specify requirements for external customer", the associations are positive for responses on "Management, Design and Development", and "Provision of computer services" (H_0 rejected at $\alpha < 0.01$ and $df = 4$).

3.8 Other Observations

While the general picture shows that "interest", "involvement" and "knowledge of ISO 9000" are key elements or factors associated with quality management practices, the analysis also identified other issues that need to be addressed.

Of the 411 selected organisations and companies in the mailing list, 224 (55%) were "Top 200" companies in 1991, 1992 or 1993. Of the 140 respondents, 45% (63) were among the top 200 companies, therefore, only 28% of all the selected top 200 companies in the mailing list participated. This figure is surprisingly low.

The "Manufacturing" industries were perceived to perform significantly better in some of the quality management system features (H_0 rejected at $\alpha < 0.01$ and $df = 4$). These features included "defined and documented quality policy for the provision of computer services" (p value = 0.006) and "quality system includes standard methods for developing documentation during design and development" (p value = 0.002). This is not unusual, as manufacturing industries often operate quality systems.

Small organisations and companies (total staff size less than 10) demonstrated significantly higher "degree of interaction" between computing services providers and customers (p value = 0.005, H_0 rejected at $\alpha < 0.01$). Small organisations and companies often rely on advice and support from providers (Cragg and King, 1993). Typically, computing services providers supply the computer hardware, software packages, technical support, and training of users. Empirical studies have revealed the important influence that provider effectiveness has on IS/IT success in small organisations and companies. Yap et al (1992) found that IS/IT success is positively associated with the level of provider support in small organisations and companies.

There were also observations, such as, responses with a significantly ($\alpha < 0.01$) high level of "senior management commitment to quality" were received from:

- the "Business and Financial Services" sector,
- the "Community and Social Services" sector,
- "companies working towards a quality standard for their computing services",
- respondents with a high level of "involvement in quality management practices", and
- respondents with a high level of "knowledge of ISO 9000".

The factors, "computer staff size of 21 or more" and "certified to a quality standard" were marginally associated with quality management practices. There were 29% (41) of respondents that had "21 or more computer staff". Only the "Design and Development of Computer Services" (DIII) and "Provision of Computer Services" (DV) were significant ($\alpha < 0.01$). There were 42% of the respondents "with computer staff size of 21 or more" that responded with level 3 and above on quality management systems features.

From some of the typical comments made in the responses, it may be summarised that all organisations and companies recognised the importance of quality management practices. Some organisations and companies were motivated by improving their performance and quality of customer services. However, there were reservations about the usefulness and benefits of quality management practices and their ability to cope with the rapidly changing IS/IT environment. There were concerns on whether the effort and expenditure on quality management practices would be worthwhile or even feasible for small organisations and companies.

3.9 Discussion

The research survey indicated that a large majority of organisations and companies were very interested in quality management practices. There was staff acceptance of, management support and management commitment for quality management in computing services. However, the "involvement" and "knowledge" of quality, quality management and quality system

standards was limited and the responses were varied. The average response to the "involvement" and "knowledge" questions were "use them occasionally" and "familiar, but don't use them".

The research survey also found that general quality management perception had a direct positive association with "customer/supplier relationship" and "quality practice". Respondents with high levels of "interest", "involvement", or "knowledge of ISO 9000" achieved significantly higher levels of quality management practices.

A study done in the United Kingdom indicated that the availability of people with the vision and skills required to develop a high quality business systems is a key factor. There is a "need for education and training programmes, to establish an environment that supports high quality work". (CSC Index, 1991)

New Zealand is relatively new in the development and management of quality for information systems and information technology. The subject area of quality is growing rapidly in popularity. Government, industry groups and the NZOQ (New Zealand Organisation for Quality) have had a significant impact in their leadership roles, in the promotion of quality programmes, and in their advisory function in regard to quality issues, (Baguley, 1994).

Based on the research survey, respondents were not doing well with respect to the quality management practice features. The means and medians for most quality management practice features were consistently low (with both mean and median about 2) - "Aware of need for the quality system feature and planning commenced". The only exception was "procedures for corrective and preventive action in response to customers" (DV4), which received a higher level and a wider spread of answers (mean=2.62 and median=3). This centres the distribution around "quality system feature partially implemented and documentation in progress".

There may be several reasons for this situation. Probably the greatest contributor is that organisations and companies were at the initial stage of implementing their quality systems. This is a typical phenomenon, where organisations and companies are responding to customers needs and have just begun their journey towards quality, "customer focus", and the new way of doing business. At this stage organisations and companies had just started to apply the quality "feedback loop".

It is important for organisations and companies to progress onwards with their quality system implementations. It is not enough to have the interest and a partially built quality system. There must be continuous improvement and a quality system to keep track of the direction and achievements made. The importance of a quality management system is that it provides a flexible framework within which skills, methods, controls and standards can be applied in a quality conscious way.

Even though our present research survey indicated that very few companies had their computing services systems certified to a quality standard, there was a promising level of respondents who were working towards it (47%). The NZS 9000 series standards were the most popular. However, a small percentage of the respondents were working towards the NZS 3563: Software Quality Management System standard, TQM, CI or company internal standards.

On a wider scale, in 1993, New Zealand had approximately 750 companies certified to the NZS 9000 Standards (Walker, AJ, 1993). Since then, many more companies have obtained certification for their quality systems. A telephone survey revealed that local NZS 9000 Standards certifying bodies estimated that, in mid 1994, the number of companies certified for NZS 9000 in New Zealand was about 955. (Pang, 1994) Consequently, this research survey, which was conducted at the end of 1993, reflected the situation over the 1993/1994 period. This indicates that companies are beginning to recognise the importance of quality management systems and that the number of companies gaining certification for the NZS 9000 quality system standards is growing rapidly.

There is one other factor worth discussing, namely, the companies with more than 21 computer staff. In the survey, 41 (29%) respondents were with "computer staff size of 21 or more". This group of respondents performed marginally in achieving quality management practice features for "Design and Development of Computer Services" (DIII) and "Provision of Computer Services" (DV). An average of 45% of those 41 respondents achieved level 3 and above on the particular quality management system features.

Previous research suggests that there is a relationship between IS staff size, computing services and organisational success (Raymond, 1990). According to Thong (1993), small companies lag behind those larger organisations in the use of IS/IT due to the characteristic problem of resource poverty. Resource poverty results from smaller companies operating in a highly competitive environment, suffering financial constraints and lack of resources.

4. CONCLUSIONS

Some of the main issues and conclusions emerging from the research survey can be summarised as follow:

- There was substantial interest, staff acceptance, management support and management commitment for quality management in computing services.
- There was a general lack of people with sufficient involvement in and knowledge of quality, quality management and quality standards.
- The implementation levels of quality management system for most organisations and companies were low.
- The most common quality standards adopted by companies to build their quality systems were the NZS 9000 series standards.
- Less than 50% of the organisations and companies were working towards certification of a quality system for their computing services.

- Good quality management practices appear to be associated with organisations and companies that have staff interested and involved in quality management. Organisations and companies "working towards certification of a quality standard" were also considered to have a strong association with quality management practices.
- Organisations and companies with "one system or sub-system certified to a standard" and "computer staff size of more than 20" were perceived to have done marginally better in the area of quality management practices.
- There were perceived limitations and reservations about introducing quality management practices.

This study presents a snap-shot of the status of quality management in New Zealand industries. Any or all of the quality management, improvement and approaches may yield benefit for an organisation provided there is a climate to improve, including an acceptance by staff and a commitment of management. Without the climate to improve, organisations will fail and systems and services will remain of poor quality.

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The identification of the most useful groupware applications above supports the assumption that asynchronous groupware systems, rather than synchronous groupware systems, are more likely to improve the efficiency and effectiveness of quality management. The support to this assumption contrasts with the large amount of empirical research on groupware done so far. This research has been mostly focusing on the use of group decision support systems to support group activities, with potential application for quality management programs (Sheffield and Gallupe, 1992; Nunamaker, 1991; Beise, 1992; Pietro, 1992; Dallavalle, 1992).

3. Illustration: A Truck Parts Manufacturer

As an illustration of the use of groupware to support quality management, let us consider a fictitious Truck Parts Manufacturer called KTP (this illustration is based on an ongoing project being currently carried out in Brazil with a a company with characteristics similar to KTP). KTP supplies parts for several truck manufacturers through two plants with approximately 150 employees each, located 300 kilometres apart. Each of the plants has a computer network primarily used to run integrated financial and inventory control systems as well as general utilities (e.g. wordprocessor and spreadsheet).

As most of KTP's biggest customers require it to be certified by ISO 9002, which in turn requires a documented system of procedures for production and quality inspection of goods designed elsewhere, it decided to introduce PMQP. A plan for the introduction was outlined and the company started with three main steps: I)A training program on the PMQP's basic concepts to all employees and on some basic statistical tools to the facilitators, who were selected from among the more skilled employees identified in the basic course. II)The introduction (i.e. installation and training) of two commercial groupware systems to the plants: ProMail, which embodies electronic-mail, computer conferencing and workflow control features, and GroupDecision, a group decision support system. III)A preliminary audit performed by an official certification institute, based on the ISO 9002 norm.

Quality and groupware training sessions were combined, showing through practical examples how groupware could be used in the several tasks comprised in the PMQP's implementation. The two networks in each plant were integrated with ProMail so that users of the two plants could take part in computer conferences, control workflows involving people from different plants and exchange messages with them.

A Quality Committee was created by KTP's board of directors, constituted by the two plant managers, two representatives of the employees and two other members from the Internal Support Area, which was not formally created yet. It was decided that the Quality Committee would initially meet once a month to make strategic decisions concerning the PMQP implementation, such as assignment of people to certain roles, approval of detailed implementation plans and allocation of resources when special needs were identified. It was agreed that meetings would be performed with the use of GroupDecision, starting with the definition of the Internal Support Area (i.e. its main responsibilities and personnel).

The results of the preliminary audit, pointing out the main problems to be solved so as KTP could be certified, were distributed in the form of a report to all the employees via electronic-mail. The members of the internal support area, already selected, suggested some of these problems to be taken up by some groups of employees, forming the first quality groups. Topics describing the problems tackled by each group were created in the conferencing system, and group members were asked to carry out most of the discussion electronically. This was accomplished by the group members adding comments to the topic and exchanging messages among themselves through electronic-mail. When planned actions were required by a quality group (e.g. to put into practice agreed solutions) the group leader would schedule some activities and control their execution using ProMail's workflow control functions. All data generated would be attached to the topic, hence requiring minimum effort from the internal support staff to keep track of quality groups' development.

The documentation of the quality system was carried out at the same time as some changes in the manufacturing and inspection were accomplished so as these processes could comply with the general criteria set up in ISO 9002. The Quality Committee defined, through a meeting session with GroupDecision, the mission of the organisation and general quality standards to be followed by everyone. They were summarized in what was called the "quality letter" of the organisation and distributed via electronic-mail to everyone and later discussed among managers and front-line workers in face-to-face meetings. The QFDs were generated along with the definition of responsibilities through face-to-face interviews conducted by a group formed by external consultants and the internal support area. The results were held in ProMail as files attached to conference topics for revision, which was carried out by interviewees suggesting modifications through comments and electronic-mail messages. With this information available the same group wrote the quality system manual and the procedure specification manuals. Those manuals were attached as files to topics in the computer-conferencing system, for public access.

After approximately one year KTP was accredited by ISO 9002 on its two plants, both after the first visit of the auditors. It also had a remarkably small number of printed manuals being handled by employees, which was quite different from other certified organisations. As a result of its quality system implementation it expected to increase its international market share, and reduce costs, mainly as a result of changes proposed by quality groups. When

compared with other similar organisations, KTP significantly reduced the duration of the certification time.

4. Conclusion

KTP's case provides an illustration of groupware utilisation to support several different stages of a quality management program. This quality management program, despite being based on a specific methodology - PMQP, can be seen as a general example of a quality management program aimed at accreditation by ISO 9000. KTP's case highlights the fact that both synchronous and asynchronous groupware can be used in supporting quality management, but that asynchronous groupware holds the most potential. One explanation is that most of quality management activities require data collection and analysis over time, which is better performed in an asynchronous way, and public sharing of information, which is particularly well supported by some conferencing systems.

Groupware use on quality improvement programs is new. Few studies have been reported, with the majority about experiences with group decision support systems to support quality groups. There is a huge potential application for groupware to support quality management procedures, as the number of companies seeking quality management certification is expected to grow exponentially in the next ten years. Groupware itself is a new and rapidly evolving set of technologies, and as these technologies move from the lab to the marketplace as commercial products, there is likely to be increasing use on quality improvement and certification.

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EVOLVING PATTERN DETECTORS FOR PREDICTING RETENTION IN MANAGING STUDENT ADMISSIONS

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Abstract. *Student's responses to psychological questionnaires can be evaluated by classifiers designed to detect predictive patterns before new applicants are admitted to a school. Individual item responses and aggregate background scores provide information useful for predicting student's long-range performance. Historical records on previously admitted students and test performances can provide data for evolving of classifiers. The classifiers can be based on knowledge either in optimized population of data patterns or in the connection weights of neural network models. Expected accuracy in classification is monitored by splitting historical data into training and test sets. For management, the role played by these classifiers is to improve decision making to enhance the ratio of the graduating students to those who terminate before completion.*

Key words: retention, predict, admission, pattern, student.

1 The Student Retention Problem

There is a need for more effective criteria for screening students being accepted at academic institutions. Deciding to accept an applicant requires a valid assessment of the probability that a student will be graduated. To improve decision making, there are several methods for evolving both algorithmic and non-algorithmic classifiers.

There is now a growing basis for building computer systems that learn to classify and predict, using methods of statistics, neural networks, and expert systems [Weiss and Kulikowski 1987]. Classifiers can be derived from training data representative of students for whom performance has been established. Training data are collected from prospective students during the application process.

Classifiers may be modeled by neural networks as populations of patterns of weights or chromosomes that are improved by genetic operators. Several methods for evolving classifiers and evaluating their relative performance were tested on a data base of 200 patterns with 39, 40 and 41 variables.

2 Source of Classifier Knowledge

Typically, text-based psychological instruments designed for data collection have a few tens of items. In the available data, there were 39 items that were assigned binary values. The instrument items are designed to elicit responses which produce information necessary for building a classifier. Each response is individually scored. The scores are used in parallel to establish the potential of a particular school applicant to be retained through graduation. Evolving effective classifiers from psychological data can increase the proportion of students who complete their studies, allowing the administrators more selective in their admissions, and thereby solving the problem of retaining students.

3 Desiderata for Classifier Paradigms

It is important to develop a classifier that uses data in parallel. Typically, data variables have different sensitivities and may depend nonlinearly on the values of other variables in each instance of a pattern. The classifier must assign patterns to one of two classes of students (1) retained and (2) not-completing. To build a classifier from training data, the patterns from student application records are paired with historical logs of graduation or failure.

4 Problem and Data Description

Currently, many students begin their program of study and can not be retained to graduation. Costly waste of resources can be reduced if data available about potential students can be used successfully to favor admitting a greater proportion of students with a higher probability of being graduated. The retention problem requires a more refined application of the information available before admission. Minimizing the number of dropouts enhances the proportion being graduated.

Two main types of data are available from applicants. These data include the individual item scores and the aggregated scores. The later reflect an average over the collection of item scores or performance over a distribution of the same items spanning a period of time. One example of such an aggregate score is a student's high school grade point average.

5 Data Acquisition & Response Scoring

Psychological information is collected by a uniformly controlled presentation of a sequence of questions or items and recording the response to each. After the responses are recorded as text, the score for each item can be evaluated and assigned a binary value of zero or one, depending on whether or not an item satisfies prescribed, fixed criteria.

6 Partitioning of Training and Test Data

When a classifier is to be evolved and evaluated from an over-abundance of historical data, making decisions on how much of the data is sufficient for training is not difficult. One can simply use the largest training set sample that can be processed with the computer and available time. Then from the balance of the data, one can randomly select a sample of test patterns that is large enough to bring the confidence interval on the performance measure into an acceptable range.

7 Artificial Neural Net Algorithms for Parallel Distributed Processing PDP

Neural networks are tolerant of uncertainty and can operate with online observations to identify the class of sample patterns. These networks can learn the equivalent of rule information from examples of training patterns of many variables. Explicit coding of process knowledge as a set of symbolic rules is unnecessary.

The most common type of layered neural network model, the [Rummelhart 1986], has an input processing layer which feeds the first one or more hidden layer(s). The final active layer processes intermediate signals from the second-to-last layer to activate the output.

Fully connected, recurrent neural networks include backwards directed and/or lateral feedback connection weights. They can take the form of memory neural networks or MNNs [Unikrishnan et al 1991, 1993]. In MNNs each node has attached one or more memory neurons to produce lengthy response delays. In the training phase, the cumulative or net effect of the time-delay neurons is to learn or encode the responses that incorporate multiple time delays.

8 Alopex: Correlation-based Simulated Annealing

Simulated annealing using the Boltzmann distribution originated with the Metropolis algorithm for function optimization. Alopex [Unikrishnan et al 1991] is the name given to an algorithm that is capable of evolving improved neural network models by stochastically selected modification of weights. Alopex differs fundamentally in principle from other algorithms for systematically improving a solution model on the basis of input patterns and corresponding known outputs. Because it is more dependent on random excursions taken in solution space, Alopex has more of an evolutionary flavor than other deterministic hill-climbing approaches to model building. One architecture for an Alopex algorithm optimized network model has one or more fully connected hidden layers with node that also includes self-loops. The exponential term in this distribution depends on a measure of the correlation in the error changes and the weight change over the previous time period.

One specific example of a successful architectural structure has one output, two hidden layers of 5 neurons each, and these are fed by the 39 binary inputs that correspond with values of scores assigned to the 39 responses to items of a psychological questionnaire.

9 Memory Neural Network (MNN)

The architecture of a memory neuron network is multi-layer with recursion and internal time delays supported by feedback paths associated with one or more memory neurons attached to each ordinary network neuron. Each input node and every ordinary neuron of the hidden layers has attached a memory neuron through a time delay. Also, the inserted memory neurons all have self-loops with a time delay. The output layer neurons can have delays attached to more than one memory neuron in series and each delay is introduces in parallel to the host network neurons to which they are linked. There is no connection between network neurons within layers. The internally added memory neurons all have an output to every node in the following layers. Optimization of the weights connected to all networks on memory neurons can be accomplished by a modification of error backpropagation algorithms or evolution with a genetic algorithm.

9 Cascade Correlation (CASCOR)

The architecture of CASCOR [Fahlman 1988, 1990] has several advantages over that of the BACKPROP and QUICKPROP algorithms. CASCOR automatically determines the size and topology of the network. This method also preserves the structure it builds even after subsequent changes in the training set, and requires no back-propagation of error signals through the connections of the network. CASCOR is a supervised learning method that builds a significantly minimal, multi-layer, network topology during the training. Initially, the network contains only inputs, output units, and the connections between them.

10 General Description of LVQ Methods

Learning vector quantization or LVQ [Kohonen 1989] is a classical method for producing an approximation to a continuous probability density function p(x) of the vector input variable $\mathbf{x}$. This density function uses a finite number of codebook vectors $\mathbf{m}_i$, i = 1, 2, ... k. On specifying the "codebook", approximation the output for the input $\mathbf{x}$ vector requires finding the reference vector $\mathbf{m}_c$ closest to $\mathbf{x}$. An optimal placement of the $\mathbf{m}_i$ minimizes E, the expected value for r^{th} power of the reconstruction error:

$$E = \int_{\mathbf{x}} |\mathbf{x}-\mathbf{m}_c|^r \cdot p(\mathbf{x})\, d\mathbf{x}, \quad |\mathbf{x}-\mathbf{m}_c| = \min_i \{|\mathbf{x}-\mathbf{m}_i|\} \quad (5)$$

In general, no closed-form solution is possible for optimally placing $\mathbf{m}_i$. Consequently, one must resort to

resort to iterative approximation schemes. The LVQ algorithm uses vector quantization to define directly the class borders with the nearest-neighbor rule.

When the LVQ algorithms are used, the classification accuracy achievable and the learning time depends on the following factors: (a) approximately the optimal number of codebook vectors assigned to each class and their initial values and (b) the detailed algorithm, its learning rate schedule during training steps and some appropriate stopping criterion.

10 Results of Experimental Trials of Classifiers Produced from Training Data Using Alternative Methods

BACKPROP, QUICKPROP and ALOPEX were used for learning a classifier for predicting the binary or integer output values used for designating class in the set {0,1} or in the interval [0-8700]. ALN (adaptive logic networks) and LVQ were used to produce classifiers for the binary output. Results were obtained for the data by the six methods: (1) BACKPROP, (2) QUICKPROP, (3) ALN, (4) ALOPEX, (5) LVQ1 and (6) LVQ3. Results from the first three methods were inferior to those of the LVQ algorithm.

The best results were obtained using the LVQ3 algorithm. The accuracy, in terms of the number of correct classifications, obtained with a test set of 100 patterns is 61%. This level of performance was observed by using either 39 or 40 input variables, independent of whether the output classes being predicted were binary or integer. Two versions of the LVQ algorithm derived acceptably performing classifiers from a set of training samples. Unlike the BACKPROP, QUICKPROP, ALN and ALOPEX, which gave highly nonuniform classification results, the accuracies of LVQ results for the two classes were similar at 57 to 64 %, respectively.

For predicting binary output classes, the LVQ accuracy is superior to that of BACKPROP, QUICKPROP, ALN and ALOPEX. These four learning algorithms tend to get trapped at local minima. The undesirable tendency characterizes the behavior of these gradient and random search methods, namely: BACKPROP, QUICKPROP, ALN and ALOPEX, to produce spurious results.
In a series of experiments, with values of ϵ between 0.1 and 0.5 and values of α between 0.01 and 0.03, a window size between 0.1 and 0.4 was found effective. The optimal value of ϵ depends on the size of the window. A smaller window size is more optimal. After the definition of the codebook vectors, finding acceptable values of the parameters ϵ, α, and window size are formed through an iterative process.

The 100 training patterns had an equal number in each of the two classes. The test set of 100 patterns was split between the two classes as 33 to 67. The number of codebook vectors varied over the range 20 to 50. The number of training iterations ranged from 4,000 to 10,000. Since the level of performance obtained on the training set was 78 and 88 %, respectively, for the two classes with an average of 83%, it appears probable that the psychological questionnaire data does not have enough discriminating information to support better classifier performance.

11 Conclusions

The difficult problem of automatically creating a classifier from training samples of psychological data has explored by making a comparison of a number of evolutionary algorithms. These algorithms capture the equivalent of classification rule information from training examples. It is concluded the most reliably performing classifier was obtained by iterative generation of variants of LVQ, the learning vector quantization method.

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