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Guest Editorial

Does Today’s Industry Need Qualified Computer Scientists?

This guest editorial consists of two contrasting views on the value to industry of a professional degree in computer science. Both authors, one local and one from Germany, are managing directors of well-respected software houses. (Editor)

Viewpoint I

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D4600 Dortmund 1

I would like to begin by recounting from my student days a story that I consider to be relevant. While attending a career forum for computer scientists, mathematicians and physicists, the personnel officer from IBM Germany was asked if he would consider taking on mathematicians. The gist of his answer was as follows: "Of course I must admit that I could just as well give the mathematician's job to a theologian. What is important is the ability to think logically. It is only there, on the job, that he learns how to become productive for us."

This episode occurred 14 years ago at a time when graduating mathematicians did not necessarily learn programming and when computer scientists were few and far between. The situation has improved immensely since then. Mechanical engineers, electrical engineers and physicists, all with programming knowledge, have for the most part taken over many programming jobs. This shows industry that, as time goes by, the answer to the opening question is becoming an ever-louder and more frequent "NO."

I support this opinion and in the remainder of this essay I will expand on my reasons, as well as highlight some exceptions.

An employee who is recruited directly from a university should possess the following four capabilities:

1. An ability to think logically: One of the basic requirements in our business is the ability to recognise, analyze, structure, break down and solve a problem as well as to fully synthesize the solution. The important thing is to break down the problem in such a way that the individual components can feasibly be solved. This is what distinguishes an engineer/scientist from an arts scholar. The latter usually concentrates on the complete problem and tends to settle for a contentious, complex and partially non-feasible solution. In our business, it is not enough to merely ask the "right" questions.

2. Programming skills: Our employees' prime tool of the trade is their ability to encode solutions to problems. Ideally, this ability ought to be held as abstract as possible. In other words, the further away from the "bit", the better. FORTRAN programmers who, for example, concentrate on the multiple use of memory space of all variables will never be successful programmers in an object-oriented programming language.

The difference can be seen, even in today's universities. For example, one only has to read a PROLOG program from a student who learned PASCAL in his first semester and PROLOG in his fifth. On average, this is always a "PASCAL program in PROLOG". The various possibilities offered by a predicate calculus language are only recognised and used by the best students. Again, we do not need the average computer science scholar who has spent between six and eight years writing complicated PASCAL programs, but rather the "thinker" with basic programming knowledge who is capable of abstracting the task. Once again, the ability is independent of faculty.

3. Teamwork skills: Working successfully in a team

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requires assertiveness, tolerance, stability and one's own ideas. Very few problems have solutions that can be managed by one person successfully in the allocated time. Out of 700 employees, we can only afford approximately five "lone warriors" who are, in turn, the leading specialists in a wide field. They have a strategic vision which we follow. All remaining employees are evaluated, for better or worse, on their team performance. Some people have an in-built ability to work in teams. A few universities - unfortunately not enough - encourage this team-thinking. Again we see that the ability is independent of university faculty.

4. Motivation: The ability to enjoy one's particular job is a major driving force in every employee. Whereas in the sixties everything had to be "bigger, faster and better" and in the eighties "things had to be meaningful to society", the theme for the nineties is self-realization. Those companies who succeed in incorporating different employees (ie employees with different driving forces) into the company culture and who motivate each employee optimally will be successful in the nineties and beyond. There are huge productivity gains to be had from motivating employees. Compared with this, the possibilities offered by CASE tools pale into insignificance.

One basic requirement is thus the recruitment of a self-motivated employee who should at no stage become demotivated, whether it be by company culture, superiors or working conditions.

Again, this is not linked to a specific university faculty and is independent of know-how.

As none of these four capabilities are necessarily restricted to studies in computer science, the technical/scientific background of new employees who are being recruited is largely irrelevant.

I would now like to point out a few exceptions which might give a computer scientist the upper hand in an interview. I refer exclusively to our own company and our specific company tasks.

1. Porting our COBOL Compiler onto the latest UNIX machine from the manufacturer XY. Knowledge of the UNIX operating systems could be very valuable and enable the new employee to rapidly become productive.

2. Programming the 37th interface (special customer request) for our ISDN card. Knowledge of interface protocols or experience with protocol conversions would be very useful and could be a decisive factor. Such specialized knowledge is usually very rare.

3. Adapting our integrated office automation system to the 17th foreign language. The employee must command the language perfectly. Simply outsourcing the translation would mean that this language version could not be maintained or supported. From this example one can see that specialized knowledge not only refers to knowledge gained from computer science studies.

In the product business, it sometimes happens that computer scientists with specialized knowledge are sought. (This is almost impossible in the project business, due to the variety of tasks to be performed.) However such a "knowledge" advantage over others usually only lasts about a year. After that, the achievements of two different employees (one with specialized knowledge and the other without) tends to even out.

Most applicants who start out do not know our products, as the flow of employees in this industry is almost always from manufacturer to user. Hardware and software manufacturers often lose their products specialist to the products' users. Seldom do employees change in the other direction.

In my opinion, universities can learn two things from this essay:

1. Studies in computer science give basic knowledge that can be used in various jobs. The student should however be careful not to place all his eggs in one basket.

2. Teamwork should be encouraged more. Time allows for very few geniuses, acting as 'lone warriors', to initiate progress in our society.

I have taken the liberty of basing my interpretation and answer to the opening question on my own judgement and experiences. I would be grateful for other opinions and experiences on this topic.

I would like to conclude by expressing my gratitude for having had this opportunity to express my views.

______________________________

Viewpoint II

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Grinaker Informatics, P.O.Box 29818, Sunnyside, 0132

The title question currently generates as many viewpoints as a counterpart question: "What is the correct curriculum for a computer science qualification?" Such questions stem from the many and diverse requirements expected to be fulfilled by the still developing applied science. A basic assumption of this editorial is that we need to have an explosion and consolidation in computer science theory. Only after this has occurred will a more general consensus of opinion exist - as is the case in other matured sciences.

An argument is presented here for the current approach of striving towards a balance between immediate industry needs and long term perceived theoretical requirements of industry, even though the balance, as viewed from either side, will always be imperfect.

Industry can, of course, do without qualified computer scientists - that is how it was established. Dedicated mathematicians, physicists, engineers and other scientists will, as in the past, continue to effect improvements. However, as one of those scientists from the
early days, it is difficult for me to understand why one would choose to continue this way.

A computer science qualification is viewed here as a university education (4 years) into theory that is not obtainable otherwise. By definition, therefore, a qualified computer scientist is not trained to conform to specific job requirements. Rather, the computer scientist will possess knowledge that will serve him long past the present day's computing technology.

Whether industry needs qualified computer scientists depends on two issues. Firstly, can an education be provided for computing technology that will serve as a foundation for the student's next 45 years in industry; and secondly, can industry build upon this foundation to create wealth more effectively than without qualified computer scientists.

It is widely accepted that, in broad terms, the teaching of fundamental theory will serve the first purpose. However, what subject matter to include from the wealth of mathematics, physics, OR, and from computing fields such as networking, operating systems and others, remains the illusive issue. Universities can merely strive to select the right mix for the perceived future needs of industry. This requires insight into the evolution of computing technology. I will later discuss such insight as a basic requirement for a qualified computer scientist.

What is important in teaching is to focus on fundamental theory. Just as the natural science student needs to breed fruit flies in order to gain insight into the dynamics of inheritance, so too the computer science student needs to develop software. The purpose should be to create understanding and insight into fundamental theory, and, just as in the case of the breeder of fruit flies, the software developed should never be measured against efficiency requirements from industry.

The second issue is whether industry can build on this theoretical foundation to create wealth.

A depth of insight into computing technology, more so than with other training, can be identified as the focus of the potential value of a qualified computer scientist to industry. Three areas which require such insight are discussed below, namely organisation, product definition and the application of new computing technology in industry.

Computing products form an integral part of an organisation, and represent a significant capital investment aimed at increasing efficiency. These products are incorporated in an evolutionary way to match changing organisational requirements with improving product capabilities. Decisions to use products determine the long term efficiency and cost-effective replacement. Such decisions require insight into computing technology and its evolution. A qualified computer scientist can improve such decisions only if he gains enough insight into computing technology as well as its interaction with business through years of practice.

The success of products in some areas is dependent on market requirements which depend on computing technology and its evolution. The correct definition of characteristics of products that interface to computers is such an example. Insight into computing technology is able to create the versatility, simplicity or other improved selling features which can open new market segments.

The third area where insight into computing technology plays an important role is in the application of new computing technology (or a new trend) in an organisation. Examples include the introductory period for networking, DBMS-technology, distributed processing and document image processing. In areas such as these, the newly qualified computer scientist can be applied effectively and at the same time build up insight through experience which he will require for the other areas of organisational and product decisions mentioned above.

A major dilemma in the continuous development of insight into computing technology by qualified computer scientists is their correct application in industry. The identification of the opportunities within the three areas discussed above, requires insight into computing technology itself. Winning companies that depend on computing technology have this ability. In such companies the insight of the qualified computer scientist into computing technology as well as its contribution to the business is constantly stimulated, turning the qualified computer scientist into a valuable company resource.

What has been neglected in this whole discussion is the role of the "technician" and of the casual user of computing technology. Such personnel are required to implement selected computing technology of the day efficiently, whether in accounting, chemical engineering or other specialised disciplines. Their role and place is unquestioned. However, it cannot be expected of them to evaluate the potential of new computing technology, formulate algorithms from fundamental theory or any such decisions which require insight built upon a sound theoretical knowledge of the field.

The final aspect in answering the opening question is whether the qualified computer scientist can outperform other professionals who build up their own experience in computing technology. Many examples could be cited of improvement brought about by non-computer scientists in the past. However, these individuals formed part of the bootstrapping for computer science theory and education. We should have faith in this bootstrapping of computer science qualifications, because computing technology will increasingly diversify into many directions of specialisation in years to come, each requiring a body of fundamental theory.

This complexity cannot be left to a casual development of insight - industry requires qualified computer scientists to experience interaction with business objectives in order to cope successfully with future computing technology.
A Causal Analysis of Job Turnover among Systems Analysts

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Abstract
Staff Shortages in the Information Systems industry are a continuing problem. Job turnover of IS staff contributes to this shortage and is particularly high in South Africa. This high turnover is often attributed to inadequate remuneration. A study was conducted to determine the reasons why Systems Analysts leave their jobs. The results demonstrate that these individuals consider career growth and job content more important than salary. As these factors can be controlled by IS managers, certain actions are proposed to reduce the high turnover.

Keywords: System Analyst, Job Turnover, Staff Shortages, Remuneration
Computing Review Category: K.1.1

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1. Introduction
There is currently a worldwide shortage of experienced Information Systems (IS) personnel. Jenkins [13] predicted that the numbers of IS personnel in the United States of America would grow from 240 000 to 400 000 by 1990, and estimated a shortfall of between 15% and 20%. In Britain it was predicted that in 1985 there would be an shortfall of 16% in a population of 43 000 Systems Analysts [1]. The total IS population in South Africa was estimated to be 38 000 people by 1990 [18]. Of this number, approximately 2800 would be employed as Systems Analysts. In a recent local survey, Bayer reported shortages of between 20% and 30% depending on job title [5]. There has been no evidence to dispute any of the above predictions which indicate a 1990 undersupply of Systems Analysts of 700 in South Africa, 6880 in Britain and 13,000 in America.

These shortages are made even more severe if one includes the added problem of staff competency. For example, 15% of IS staff were rated as below-average performers in South Africa [18]. Given the shortages and the resultant low productivity, it is the responsibility of IS management to ensure that all possible causes of employee dissatisfaction that are under his control are addressed. This implies an awareness of those causes of dissatisfaction. This is the purpose of the study - to identify the reasons why Systems Analysts leave their employ.

The research problem developed from the authors' belief that factors other than salary contribute to the high turnover of Systems Analysts in South Africa.

2. Prior Research
Job turnover can be caused by many factors [17]. These include economic factors such as high levels of inflation and unemployment. Organisational factors such as the reward system and job design and individual factors such as career needs, family requirements, individual expectations and individual abilities also contribute to job turnover.

Specific IS research into staff selection techniques [14], motivation issues [9][8], and reasons for job turnover [3] have provided some understanding of these behavioural problems. The conclusions indicate that IS personnel have different career and job requirements compared to other professions.

Research into how IS people are motivated [9], how they should be managed [4], and the identification of personality characteristics [14,16,24] suggests that IS personnel view the nature of their job, their career achievement and their career growth as key factors in their job situations. Bartol [3] concluded that job satisfaction was the key predictor of turnover, although other factors such as organisational commitment, professionalism and organisational reward systems were also important. Salary was considered to be important in a survey by Bartol and Martin, but it was viewed as an indicator of the level of recognition given to IS staff and not as a primary motivator [4]. Couger [7] argued that each individual's need for growth should be balanced with their job enrichment and enhancement.

Garden [12] identified money as the primary cause of dissatisfaction although challenging and interesting work were also prominent factors. She concluded that Systems Analysts want both job challenge and financial rewards and were not prepared to compromise on either factor.
3. Research Methodology

The research involved an empirical study to determine the reasons why Systems Analysts leave their jobs. The method employed was to send a questionnaire to people involved in the IS industry. The first issue was to define the term "Systems Analyst" adequately so that there would be a common understanding amongst the research respondents. The range of skills and jobs in the IS industry makes the definition of unique terms difficult. Job titles can vary for the same job, and job content can vary within the same job title [22]. The job of the Systems Analyst is considered critical and highly complex in the industry and requires considerable administrative and people skills along with the technical skills [10].

The following definition was developed based on those of Lucas[15] and Vitalari and Dickson[21]:

"An individual who analyses organisational information requirements and conceptually designs a computer-based information system to collect, store, and disseminate data in support of organisational goals".

To ensure certain Business Analyst and Analyst/Programmers jobs were also considered, the definition was modified as follows:

"An individual who spends at least 50% of his work effort carrying out the above". [20]

Three possibilities existed for obtaining data on the job turnover of Systems Analysts. The first two, employer exit interviews and individual interviews with the Systems Analysts themselves were rejected due to the difficulties of accessing sensitive information and obtaining forwarding addresses. The third alternative was to approach Computer Personnel Selection agencies. This was viewed as a rich source of data as the authors felt that the intimate job interview between the agency and the applicant could provide not one but several reasons for each Systems Analyst changing jobs. It was also felt that the personnel consultants have a professional understanding of the individuals concerned. This approach had one drawback in that it would not capture the instance where a person emigrates because of political or social convictions. Given the turbulent South African situation, and the large number of job opportunities in other countries, it was accepted that although the number of emigrants was probably large, it was not controllable by IS management.

From a literature search, a list of twenty reasons why Systems Analysts leave their jobs was compiled (see Figure 1 for a list of these reasons). This list was discussed with a prominent computer personnel consultant, who checked the wording and completeness of the list. The list was then transformed into a questionnaire requesting the respondents to rank the reasons in order of importance and add further reasons if any. The respondents were asked to put a percentage against each reason to represent its relative importance in the list. Similar percentages and large gaps between percentages were permissible. This provided both a ranking and a rating for each reason.

An analysis of South African computer newspaper job advertisements was carried out to identify prominent computer personnel consultants. From this group, 30 were selected and a questionnaire sent to each of them.

4. Analysis of Results

Eighteen usable replies were received from the thirty questionnaires sent out (a 60% response). Although additional reasons were offered by respondents, they were considered as either equivalent to those already on the list or they were viewed by the respondent as being of minimal importance. Several respondents expressed difficulty in completing the questionnaire especially with the overlap of several reasons.

The reasons were ranked for each respondent and the data was entered into a spreadsheet. The median, mean and standard deviation were calculated for each reason (see Figure 1).

Each response was then ranked in order of importance from 1 to 20 and the collective median, mean and standard deviation calculated for each reason. The results are shown in Figure 2. This was to investigate the effect of removing the weightings for each reason. From Figure 2, a value was calculated for Kendall's Coefficient of Concordance (W). This coefficient measures the level of agreement between the rankings of the respondents. The high value of 0.95 suggests that the group were in very close agreement[19].

The results in Figure 2 correlate very closely with those in Figure 1. With a few minor changes in the order, the top ten reasons can be grouped into "job content", "career issues" and "unsatisfactory remuneration". The dominant category is "career issues" with 5 of these factors featuring in the top 6. By contrast, "unsatisfactory remuneration" was rated 8th overall; it was identified as the most important reason by only 2 respondents and was placed in the 5 top reasons by only 5 respondents. Although the standard deviations, as expected, are high (because of the expected wide range of subjective opinions), the overall rankings in the two figures are very similar.

If "career issues" and "job content" are the main reasons that Systems Analysts leave their jobs, then IS managers are in a position to tackle the problem. Developing short-, medium- and long-term career paths for individuals along with challenging, clearly-defined jobs must help to reduce turnover.
<table>
<thead>
<tr>
<th>Reason</th>
<th>Median Score</th>
<th>Median Rank</th>
<th>Mean Score</th>
<th>Mean Rank</th>
<th>Std Dev</th>
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<tr>
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<td>80</td>
<td>1</td>
<td>69</td>
<td>1</td>
<td>33</td>
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<td>New challenge/stimulation</td>
<td>71</td>
<td>3</td>
<td>66</td>
<td>2</td>
<td>29</td>
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<tr>
<td>Better long term career prospects</td>
<td>73</td>
<td>2</td>
<td>61</td>
<td>3</td>
<td>39</td>
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<tr>
<td>Limited future growth</td>
<td>66</td>
<td>5</td>
<td>60</td>
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<tr>
<td>Career development</td>
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<td>57</td>
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<td>63</td>
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<td>Broader experience</td>
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<td>7</td>
<td>51</td>
<td>7</td>
<td>33</td>
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<td>45</td>
<td>8</td>
<td>47</td>
<td>8</td>
<td>33</td>
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<tr>
<td>Move into management</td>
<td>32</td>
<td>9</td>
<td>33</td>
<td>9</td>
<td>27</td>
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<td>Lack of recognition/feedback</td>
<td>23</td>
<td>10</td>
<td>26</td>
<td>10</td>
<td>27</td>
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<tr>
<td>Unhappy with management after restructure</td>
<td>20</td>
<td>11</td>
<td>31</td>
<td>11</td>
<td>27</td>
</tr>
<tr>
<td>Personality Clash</td>
<td>8</td>
<td>13</td>
<td>21</td>
<td>12</td>
<td>27</td>
</tr>
<tr>
<td>Move to new city</td>
<td>12</td>
<td>12</td>
<td>13</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Frustrated with design changes from above</td>
<td>3</td>
<td>18</td>
<td>13</td>
<td>14</td>
<td>19</td>
</tr>
<tr>
<td>Lack of structure with regard to methodology</td>
<td>3</td>
<td>19</td>
<td>12</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>Overseas job/travel</td>
<td>6</td>
<td>14</td>
<td>11</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>Leave civil service</td>
<td>4</td>
<td>17</td>
<td>10</td>
<td>17</td>
<td>14</td>
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<tr>
<td>Start own business/consulting/contracting</td>
<td>5</td>
<td>15</td>
<td>10</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>Required to learn new technology</td>
<td>0</td>
<td>20</td>
<td>5</td>
<td>19</td>
<td>10</td>
</tr>
<tr>
<td>Retrenchment</td>
<td>5</td>
<td>16</td>
<td>5</td>
<td>20</td>
<td>7</td>
</tr>
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</table>

**Figure 1** Medians and Means of Actual Scores

<table>
<thead>
<tr>
<th>Reason</th>
<th>Median Score</th>
<th>Median Rank</th>
<th>Mean Score</th>
<th>Std Dev</th>
<th>Mean Rank</th>
</tr>
</thead>
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<tr>
<td>Better long term career prospects</td>
<td>2.50</td>
<td>1</td>
<td>3.78</td>
<td>2.92</td>
<td>3</td>
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<tr>
<td>Lack of promotional prospects</td>
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<td>2</td>
<td>3.56</td>
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<tr>
<td>New challenge/stimulation</td>
<td>3.00</td>
<td>3</td>
<td>3.50</td>
<td>2.69</td>
<td>1</td>
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<tr>
<td>Career development</td>
<td>4.00</td>
<td>4</td>
<td>4.61</td>
<td>3.27</td>
<td>6</td>
</tr>
<tr>
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<td>4.11</td>
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<td>4.06</td>
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<td>4</td>
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<tr>
<td>Broader experience</td>
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<td>7</td>
<td>5.61</td>
<td>3.53</td>
<td>7</td>
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<td>Unsatisfactory remuneration</td>
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<td>8</td>
<td>5.72</td>
<td>3.35</td>
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<tr>
<td>Move into management</td>
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<td>7.83</td>
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<td>Lack of recognition/feedback</td>
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<td>Move to new city</td>
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<td>11.11</td>
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<td>12.89</td>
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<td>10.89</td>
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<td>Start own business/consulting/contracting</td>
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<td>Leave civil service</td>
<td>14.00</td>
<td>20</td>
<td>12.22</td>
<td>4.71</td>
<td>18</td>
</tr>
</tbody>
</table>

Kendall's coefficient of concordance (W) = 0.95 for SIG < 0.001

**Figure 2** Medians and Means of Ranked Scores

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5. Conclusions

This research has demonstrated that Systems Analysts consider issues of career and job content to be more important than remuneration. These conclusions should be viewed in the context of a relatively small sample and a subjective questionnaire. The sample could also be incomplete because a proportion of systems analysts do not use Computer Personnel consultants. The findings should thus be viewed broadly.

As reported earlier, prior research on the job turnover of Systems Analysts reported conflicting viewpoints regarding the importance of remuneration. The results of this South African research confirm the findings of Bartol and Martin [4] and Couger and Zawacki [9] who also identified job challenge, achievement and growth as essential motivators for a Systems Analyst with remuneration being a less important factor. The results of this research also correlate closely with the findings of Woodruff [23] who concluded that career development and career growth were key factors.

Given the additional factors unique to the South African computer industry that have already been discussed, it is imperative that maximum productivity is obtained from this very small (and therefore vulnerable) Systems Analyst population.

This research indicates that IS Managers and Human Resource Managers can have considerable influence over the level of job turnover of Systems Analysts. This level can be reduced by addressing the key needs of Systems Analysts. Effective career planning and setting challenging assignments and projects are important. Ensuring that the high individual "growth needs" are catered for will also require the development of effective job descriptions and the setting of specific objectives which can be properly measured through counselling, training and appraisal. The rewards for putting in the management effort appear to be very high.

References

Notes for Contributors

The prime purpose of the journal is to publish original research papers in the fields of Computer Science and Information Systems, as well as shorter technical research papers. However, non-refereed review and exploratory articles of interest to the journal's readers will be considered for publication under sections marked as Communications or Viewpoints. While English is the preferred language of the journal papers in Afrikaans will also be accepted. Typed manuscripts for review should be submitted in triplicate to the editor.

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  - author's initials and surname;
  - author's affiliation and address;
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