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A Recommender Systems Approach to Optimising Career Pathways Development Planning for Youth in Emerging Knowledge Economies

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Abstract— **A key resource in emerging regions is the intrinsic knowledge potential of its youth. For the potential of this resource to be fully realised, we believe that there should be a systemically designed national career pathways development system (NCPDS). An NCPDS can help channel each young person into a career best suited to that individual, whilst giving consideration to career choice and national needs. This paper discusses an NCPDS founded on knowledge-based decision support systems and evolving recommender system frameworks, able to handle large volumes of data and provide analytics. We discuss an initial prototype designed and implemented in New Zealand.**

Keywords— **Career Pathways Development, Knowledge-based Decision Support Systems, Recommender Systems, ICT4D in emerging regions**

I. Introduction

GDP growth in Emerging Markets (EM) has surpassed that of advanced economies since 1999. After the global financial crisis in 2009, this gap has further widened and is currently at 4% which is around twice that of the GDP growth in advanced economies [30]. Furthermore, almost all of the 2000-2020 growth of around 1.5 billion people in the consumer class (defined as persons with annual incomes exceeding US$6,000, in 2007 terms) is expected to come from emerging regions [30].

EM's Growth in the internet economy will be even more dramatic with its share expected to grow to around 50% by 2020 from a modest base of 6% in 2000 [30]. Four emerging economies namely Sri Lanka, China, Vietnam and Indonesia are amongst the fastest improving performers in terms of the 'Networked Readiness Index' (NRI). The NRI measures the degree to which developed and developing nations are leveraging ICT to improve competitiveness [4]. As of 2011, Sri Lanka was the fifth fastest-improving country [30].

Vigorous growth, such as that seen in emerging markets occurs when vast improvements in productivity take place due to the endeavours of human capital [20]. This human capital theory of regional growth emphasises that people are the key force behind regional growth. It argues that growth arises not by reducing costs for doing business but by utilising skills of highly educated and productive people [15, 20].

II. The Practical Problem

Young people need adequate knowledge, skills, and information on careers to successfully make the transition from school to work [16]. World leaders have for many years, expressed concerns and a desire to find solutions to the problem of directing youth to suitable careers, with a view to avoiding problems that would otherwise ensue. Many studies have found a clear connection between the economic success of countries and their human capital [10], which is often measured by the level of education in a country. The importance of educating youth, including in vocational training and apprenticeships, and gainfully utilising them is evident from the following statements. President Obama stated the follow at a Joint Session of Congress (February 24, 2009):

> *"I ask every American to commit to at least one year or more of higher education or career training. This can be community college or a four-year school; vocational training or an apprenticeship. But whatever the training may be, every American will need to get more than a high school diploma."*
>
> President Barack Obama [24]

The Minister for Civil Society in the UK, Nick Hurd, takin on the responsibility for a cross governmental youth polic stated, that it is in everyone's best interest for youth to achie their potential with the country fully supporting then especially as today's teenagers are growing up in a much mor competitive world, than did previous generations [14].

> *"The world around us really belongs to youth, for youth will take over its future management. Our children must never lose their zeal for building a better world. They must not be discouraged from aspiring toward greatness, for they are to be the leaders of tomorrow."*
>
> Mary McLeod Bethune, 1963 [3]

Pope Francis addressing the world youth day, in Rio d Janeiro (July 2013), further observed that societies can reali the potential of youth only if they knew how to give them t space, and knew how to make them *not feel isolated* fro society, family, culture and future dreams [27].

We note that recently published high ranking journals in t discipline of Information Systems have very limited literatu on CPD. It is time that an information systems solution to thes problems of CPD be sought, allowing vast amounts of data t be analysed, resulting in each individual pursuing a self-chos direction, finding motivation due to hope of success, and mo importantly feeling valued and cared for.

The rest of the paper is organised to first investigate Care Pathways Development (CPD), especially factors that influen youth when exploring career prospects. Next, look knowledge-based decision support system frameworks a evolving recommender system frameworks that incorpora data mining to form the foundation of the National Care Pathways Development System (NCPDS), followed by description of the conceptual framework designed, and t prototype implemented. Finally the evaluation of the prototy done to prove its utility is discussed. Guidelines of a mult methodological information systems research approach w followed in this research [2,12,13,23].

The purpose of this preliminary study is to plant a seed f future research. The system proposed needs to be implement at a national level in different locations of the world, to lea from one another and evolve, especially in emerging regio

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where ICT enabled development is growing fast. If processes and systems are designed and implemented to assist young adults, we believe that each country within these regions will prosper along with its youth.

III. Career Pathways Development (CPD)

Career planning normally commences in youth and continues as a life-long process in which a person takes on different roles and deals with dynamic changes [8, 28]. CPD is primarily, the interaction between a person and the varied environments that surrounds one over time allowing best use of career opportunities [7]. CPD traditionally is a person-centred phenomenon that exists only if the individual pursues it [7], although influenced by many factors as identified in research.

Besides personal interests, age, gender, personality, skills, abilities, work experience, culture, economic need, and family influences, [22] opportunities provided to persons early in life through secondary and tertiary education programmes were found to have a significant influence on CPD of an individual [7,21]. Discrimination during early years also had a major role in one's career selection [22]. The degree of participation in career-related activities such as information gathering on available appropriate career pathways, attending career planning workshops, receiving individual career counselling and career testing were all found to have a huge impact on the quality of planning done before a selection of career was made [8,31]. Prior research has identified that of particular interest to youth were: future job prospects, work-values encompassing intrinsic interests, contribution to society, high remuneration and prestige [8,28]. Guidance and directions provided by governments through scholarship opportunities, availability and location of courses, competition for access to courses and information they had of such opportunities available were also found to influence the final career choice. It is impossible for humans to simply collect and analyse this vast amount of information for each individual seeking personalised career pathways recommendations, thus pointing to the need for a data mining embedded IS approach to provide a solution.

IV. Shortcomings of Existing Computerised CPD Planning Enablers

Practical observations of existing CPD systems revealed that most were neither efficient nor effective in providing personalised recommendations by matching a country's future skills requirements with skills and interests of an individual. A knowledge base coupled with an intelligent facility to match these two needs is crucial not only for individuals looking for support in deciding on future careers but also for governance, to provide direction and planning of future educational programs at all levels of educational institutions. Therefore a national CPD system (NCPDS) centrally implemented and maintained within an emerging region seems vital.

As supported by past literature, it was quite distressing to observe that content available in such systems, on courses provided by different institutions and pre-requisites needed, were not up-to-date, was not available or was too difficult to find [1,6,30]. Information relating to how one could transition between careers by improving qualifications was not available. Individuals interested in following non-academic careers had difficulty in finding clear guidance on vocational training opportunities provided by technical institutions [7]. The systems currently in place did not have an embedded method to assess an individual's abilities and provide dynamic recommendations. This was found to be a shortcoming of CPD systems especially as some youth seemed not to know what they were hoping to do in the future [1,6].

Current CPD systems did not allow collaboration with others that an individual may look up to for guidance, such as parents and educators. Such systems did not provide crucial knowledge needed by parents or careers advisers for example on how courses in schools relate to their children's plans for transition to tertiary studies or careers [6,9,22]. Educators have limited time to access knowledge on career pathways development and are unable to devote vast amounts of time collectively needed to support each individual [6,9,21]. However, despite time constraints experienced by supportive advisors, incredible amounts of time was spent by them getting to know each individual student's background information in relation to their career aspirations [6,9,21], and to educating themselves with careers information needed to make knowledgeable decisions to provide specific guidance [6,9,21].

The key problems of CPD identified above can easily be addressed through a systemic information system, enabled to communicate with needed external data sources, store large amounts of data and analyse complex information gathered. The purpose of the NCPDS described in this paper is to address these issues of value to key stakeholders such as learners, advisors, governors etc., as mentioned.

V. Knowledge-Base Decision Support Systems and Recommender Systems Frameworks

Knowledge-based DSS (KBDSS) and Recommender Systems (RS) form the foundation of the NCPDS. DSSs are highly interactive, computer-based information systems. They incorporate components such as interfaces, models and solvers supported by robust databases to solve even unstructured and complex problems of identified stakeholders [18, 32].

DSSs that incorporate intelligent functions to capture, analyse, generate and use knowledge in a knowledge-base are known as knowledge-based DSS. A knowledge-based component can incorporate expert domain knowledge as well as data mining algorithms to support expert decision-making.

An RS is viewed in this study as an extension of a KBDSS enabled to provide personalised, evolving recommendations. Recommendations in an RS can be generated using two key approaches: collaborative filtering approach and knowledge-based approach [33]. The collaborative filtering approach assumes that human preferences are co-related and gives personalised recommendations in real-time to one user, based on preferences of like-minded users [33]. The knowledge-based approach derives its personalised recommendations using knowledge items stored in knowledge bases by answering two questions: "What does the user require?" and "What knowledge item best fits those user requirements?" [25, 26].

VI. Conceptual Framework for a NCPD System

The conceptual framework of the NCPDS (Fig. 1) was built on DSS/ RS-hybrid combined frameworks used in recommender generating online learning systems (REGIONLS) [26]. The NCPDS has a comprehensive database, a knowledge base, a solver base and an interactive interface similar to the DSS framework [32]. The main solver in an NCPDS is a hybrid recommender system [33]. This hybrid RS has a ***collaborative filtering-in sub-system, and a knowledge-based filtering-in subsystem as in REGIONLS*** [25,26]. ***A content filtering-out subsystem was introduced in the NCPDS framework,*** which enhanced the NCPDS by making information retrieval more effective and efficient as it excludes irrelevant facts, when generating recommendations. The ***filtering out subsystem is an***

effective query optimising module that has semi-processed information proactively collated in views using a similar concept to data warehousing.

An individual using the NCPDS not only learns how best to use the NCPDS but also plans a career pathway by considering several options interactively, if desired, with identified caregivers. That is, it allows an individual to acquire cognitive learning about CPD matters in a holistic manner, within a social context in a moderate constructivist environment similarly to REGIONLS. It is also able to gather and analyse gleaned or explicitly stated user feedback, at specific points in the system, generating recommendations in complex decision making situations similar to REGIONLS [25,26]. Information presented and the recommendations given to stakeholders is by analysing and making sense of the huge amounts of data collected from many identified external and internal knowledge sources. The design and implementation of the system is systematically discussed in detail in the following sections.

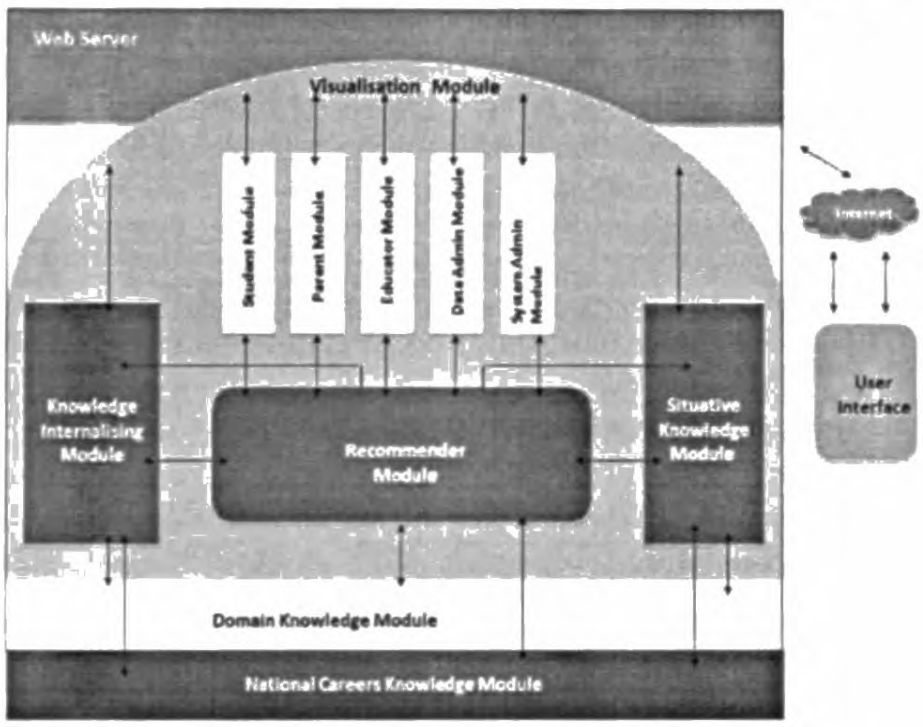

Fig. 1 CPD Conceptual Framework adapted from Peiris, et al., 2008

Firstly we addressed the problem of big data: designing a comprehensive database, developing procedures to capture all data, and meticulously maintaining transactional databases. In designing the database, a survey of many hundreds of students, and interviews of over 60 careers advisors in schools and over 12 state educational officers was undertaken. Thus a thorough requirements engineering exercise was done, and vast volumes of structured and unstructured data needed for decision making and generating multiple recommendations were identified.

It was important to understand information needs of students, parents, career advisers, educational institutions, the regions and the state. Information on professional careers was easier to obtain than information on business careers. The latter was mostly obtained from online sources for this exercise. It was also difficult to gather future government plans for "required job" categories. The data we used in the prototype was not as comprehensive as we would have liked, and was mainly gathered from government department websites and from personnel working in these departments. An NCPDS that is "fully in production", will need "government and employer buy-in" to rigorously gather information needed.

Information about courses available in institutions and pre-requisites for those courses was not too difficult to gather, as most institutional data is available online in New Zealand. Vocational courses and apprenticeships available and pre-requisites needed for these, were harder to find than envisaged.

The surveys and interviews helped to identify what data must be gathered from all stakeholders; in matching courses available in secondary schools to courses available in tertiary institutions; and for allowing career aspirations of students in secondary and tertiary colleges to be recorded. This part of the study was slow and tedious but well worth the effort.

Once the transactional database was designed and implemented, the NCPDS knowledge bases, solvers, and visualisations for portals used by different stakeholders was built. Handling huge amounts of data and designing the data analytics infrastructures was a challenge, and was addressed using an RS framework, which incorporated data mining [33].

The main modules of the NCPDS conceptual framework is shown in Fig. 1. The Domain Knowledge Module stores, and maintains all data and knowledge bases on courses and career profiles: this includes, career prospects, academic pathways available to prepare for a career, pre-requisites in qualifications and knowledge needed, courses and their pre-requisites available, educational institutions - their locations and facilities financial information - including fees, scholarships and financial support available, and career transition information are included in courses and career profiles. Details such as personality traits required, student needs catered for, skills and experiences required for a specific career, are also included within career profiles created in this module. The National Careers Knowledge Module was created to store information on national skills requirements. Portals developed in the visualisation module will allow stakeholders direct access to read data in these two modules with special access rights being granted to those who have to maintain data in this module.

The Knowledge Internalising Module stores and maintains all information about an individual seeking a career pathway. It stores student profiles, and student advisor (including parent) profiles, historical data from searchers recently done, time-stamped rankings provided by an individual for each identified factor regarding a student, and from different perspectives such as self, educators and parents. The Situative Knowledge Module stores and maintains all information regarding feedback and opinions of others about a career selection. This allows information to be gathered from parents or career advisors to be compared with self-registered information to debate the best matches. This information will be used by the recommender module to generate appropriate recommendations, as discussed later.

The Visualisation Module houses the portals through which stakeholders have access to the system. It directs a user to a specific and customised application developed for each stakeholder group. The Recommender Module is the solver that allows specific and targeted recommendations to be generated currently by four recommender engines. These are the Collaborative-Filtering Recommender Engine (CFRE), the User-Feedback Recommender Engine (UFRE), the Content-Based Recommender Engine (CBRE) [25,26] and the Business Intelligence Recommender Engine (BIRE). The CFRE works closely with the Situative Module and has solvers to generate career pathway recommendations based on aggregated feedback from others with similar profiles.

The UFRE analyses user-feedback to derive and generate new knowledge delivered as recommendations to targeted stakeholders. The CBRE generates recommendations based on knowledge derived from content. For example, recommending which career is best suited for which type of personality, and what courses will best prepare a person for a chosen career. Content-based recommendations are especially useful to avoid a "cold-start", a recognised weakness in recommender systems

Recommendations from collaborative filtering given in an RS evolves and improves only with use [33]. However, a CBRE is active from the start as it is content-based, and is therefore considered as the most important recommendation-provider in a knowledge facilitating environment. It is important to note that using up-to-date content (from the domain knowledge module) is crucial for generating high quality recommendations.

The BIRE generates recommendations through business analytics to benefit all stakeholders that include policy makers. With users becoming more sophisticated and with improvements of available hardware and data mining technologies, the evolving needs of NCPDS will impact mostly on the BIRE and its data analytic capabilities.

The NCPDS framework is designed to be within a web server and client environment that has an integrated database and knowledge base. Personalised applications are planned for each stakeholder and communicated through appropriate technologies, including mobile technologies. Many characteristics of other information systems apply to NCPDS as well. These include that the system must be simple to understand and easy to use, recommendations given should avoid information overload to the recipient complying with human information processing capabilities [11], content must be updated as frequently as feasible, the system should encourage users to give explicit feedback while at the same time gleaning feedback from users' actions. Information thus collected should be used to keep the system evolving. Recommendations must be delivered at different levels of abstraction (overview, summary and detailed) to suit the needs of different stakeholders. To prove that the conceptual framework was appropriately designed to meet these requirements a prototype was implemented.

VII. PROTOTYPE DEVELOPMENT

The conceptual framework provided a thorough blueprint to construct the NCPDS prototype (Fig. 1). The web-server and client based architecture (Fig. 2) comprises all modules residing in the Oracle http server.

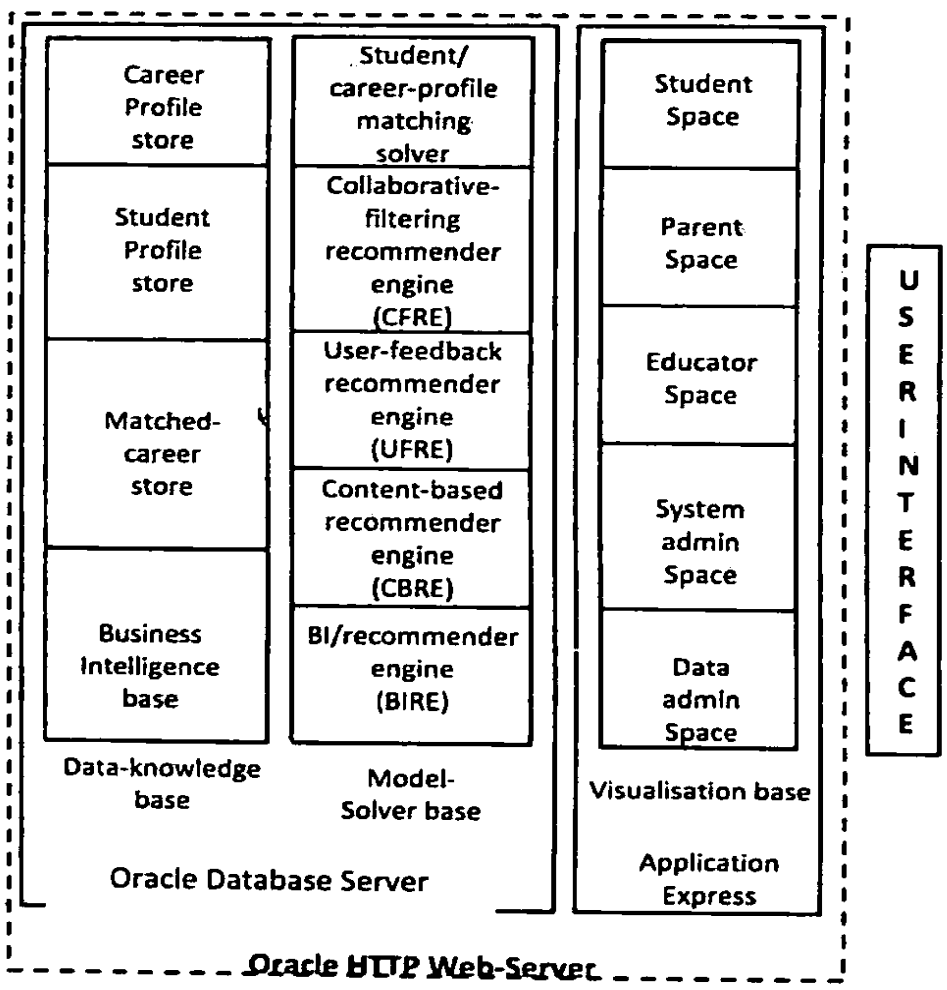

Fig 2 - CPDS Architecture

All data stores are recorded in one database within the server, with the career profile store and the student profile store being directly linked with the domain module. Some tables store semi-processed information, for example intermediate results of business analytics. This allows us to address one of the main criticisms of RS, which is the delay in generating recommendations. All the recommender engines of the recommender module are held within the model solver base. Each recommender engine presents a group of solvers needed for a specific task. For example, the student/career-profile matching is a critical solver that allows student profiles to be matched with suitable career profiles.

To prove the concepts presented, an Oracle database, and a rapid application development environment, Application Express, were used. Three of the five stakeholder portals uses the student/career-profile matching solver. These are the Student Space, Parent Space and Educator Space. Individuals using these modules were able to obtain new insights on the suitability for a specific career by ranking on 60 different criteria falling into five broad groups: personal information, interests, skills, experience, and values. These criteria can then be added to or end-dated, thus maintained to allow for evolution. The modules were integrated to provide collaborative-filtered recommendations and share opinions from supportive advisors on criteria ranking. The student/career-profile matching solver was developed incorporating a dynamic format of Genetic Algorithm (GA) application, to recommend career pathways. This was an appropriate solution as recommendations had to be dynamic and created on the run for each career pathways seeker.

Student and Career Profile-Matching Solver: initially numerous student profiles are proactively created for as many permutations as is possible using attributes that describe a student. In creating the profiles, ranges of values had to be used for some attributes (such as age). Each student profile is then matched with job suitability considering the requirements of every career in the database to calculate a measure which we named (career) suitability index. With each career having a suitability index for each student profile that exists, the database starts off in the NCPDS with a rich set of data. When a new attribute describing a student is added to the database (this must happen with evolving needs), a whole set of additional student profiles together with career suitability rankings for each new student profile are stored in the database.

Similarly when a new career is added, each student profile will check how well suited the new career is for a student that fits the profile, and the suitability index for that career will be stored with each student profile. If a criterion describing a career is updated, then its suitability has to be re-ranked for each student profile that exists in the database, and then updated accordingly. This initial matching done is quite static and considers only variables that are constant in any situation.

The dynamic GA implemented is used to consider dynamic variables. For example, for each student the costs incurred and the feasibility to pursue a particular career can be different due to the location of the degree / training venue, the location of the student, wealth of student etc. These variables can change with time as well. Such changing variables (in this application there were eight) are used as genes, together with the student profile as one gene and the career suitability index another gene.

The decoder of a GA decides which fitness function algorithm to use and which parameter values to pass for producing a ranked measure of career recommendation (ranked recommendation) for each student. The GA's fitness function component ranks how well a student matches each career

option and gives a weighting for scholarships available and costs involved etc. when generating ranked recommendations.

The same student (participant), can have different student profiles, according to who filled in the student descriptions (that is the student, parent or advisor) and at which point in the timeline of one's journey it was filled. That is, a student profile is dynamically matched to a student. The dynamic GA will then generate different ranked recommendations according to the profile created at a given time for the same student.

The careers recommended are displayed with a sequence showing the order from best to worse. The number of careers displayed can have a maximum number and is an option that can be decided. Using a database to store partially processed information significantly reduced the amount of time otherwise taken to calculate this on the run. A series of solvers were implemented to facilitate the recommendations given based on content, user feedback, and collaborative data gathered.

VIII. Evaluation

In multi-methodological information systems research, evaluation is an evolving research process. Evaluation enables researchers to locate existing problems within an artefact so that its quality can be improved [12]. The three objectives of this process are, accountability, improvement of programme and knowledge generation [29]. In relation to accountability, the major goal is to test the artefact to find out whether expected outcomes had been achieved. Formative evaluation identifies weaknesses and strengths during the research process. Enhancement of these systems using these findings, can then follow [29].

Evaluation of the evolving prototype NCPDS, concentrated on addressing the two main needs identified in field studies. These were the need for personalised recommendations and the need for an easy to use system. After researching different software evaluation methodologies one suitable for evaluating a system such as the NCPDS was selected [5,17,34].

Five attributes are adopted by ISO 9126-1 for international software quality assurance to assess the functionality of a system [5,19]. These are suitability (appropriateness of software functions for specified tasks), accuracy (ability to provide appropriate results), interoperability (ability to interact with other parties including human beings and computer systems), security (ability to prevent unauthorised access) and compliance (design of software in accordance with related standards).

A functionality analysis of the NCPDS prototype was done through a qualitative study. Three of the ISO 9126-1 attributes, namely suitability, accuracy and interoperability were considered in the evaluation. The participants of the qualitative study were 54 tertiary and high school students and three educators. They used the prototype and were encouraged to ask questions and seek clarifications regarding its functions from a demonstration coordinator. A questionnaire with nine questions was then administered to the participants to evaluate the prototype in terms of its interoperability suitability, and accuracy. Results of responses are summarized in Table 1.

TABLE I
ANALYSIS OF RESPONSES FROM THE QUALITATIVE STUDY

Evaluation Factors n=57	Positive Responses (%)	Neutral Responses (%)	Negative Responses (%)
Overall performance	73	23	4
Usefulness and accuracy of recommendations	70	19	11
Ease of use	65	26	9
Facilitation of information management	50	43	7
Facilitation of user interaction	64	26	10
Support for collaboration	45	36	19
Meta cognition support	41	33	26
Acid test – willingness to refer NCPDS to others	57	29	14

As a composite measure of suitability 73% of students provided positive responses, against 4% providing negative responses. In terms of accuracy of information 70% of users provided positive responses against 11% negative. In terms of interoperability, 64% recorded that the system helped exchange information between users and user groups, as against 10% who did not. In response to the 'acid-test' question whether users would recommend this system to others, 57% responded positively against 14% providing negative responses.

Further analysis showed that participants had largely favourable responses, for ease of use, usefulness of personalised recommendations provided, ability to manage information and inter-user communication. Meta-cognition support and facilities to provide feedback and to explore profiles were identified as weak features. The largely positive results encouraged the researchers to further develop the system learning from this experience.

The prototype was built primarily to address the two most critical problems identified by the initial field study. These were the need for personalised recommendations (identified by 100% of the field study participants) and ease of use (identified by 71% of the field study participants). In the functionality evaluations both these factors received high positive responses in the 65% - 70% range. This indicates that the main objective of building the prototype was achieved. By building a functioning prototype the framework was proven.

IX. Conclusions

The tasks of an NCPDS are complex. Personalised career advice has to be provided to individuals (students) often with guidance from either parents or careers advisors, who also have to learn about an individual seeking guidance thoroughly before advice can be given (or taken). National plans and future career availabilities have also to be considered.

Previous studies of CPDS had observed that information on career choices suited to an individual and the associated skills, experiences, and qualifications were difficult to find or lacking [1,6]. The NCPDS based on a recommender systems framework was designed to improve practices in CPD. A prototype was built as proof of the concepts presented. The NCPDS (and the prototype) particularly addresses two vital needs identified by CPD users during field studies. These were the need for personalised recommendations on careers to young adults with input from supportive advisors and the need for a system that is easy to use. In this study, we viewed the NCPDS as a dynamic learning environment that allows one to study deeply about a person by considering attributes which includes personality traits, values, skills, and qualifications and not just a passive information retrieval system.

The NCPDS allows parents and educators to contribute and collaborate in the decision-making process. Careers need to be carefully matched to an individual's traits and career-profiles. For each career recommended to an individual, supporting information such as career-pathways, qualifications to be acquired, courses available, course providers, and scholarship information were also provided. In instances where a person wishes to prepare for several career pathways, clearly setting a

ence to be followed was given. The NCPDS is designed to entually implemented at national or regional level so that nal career and skills demands can be met, and youth have r assurance of work at the end of their training. Thus the DS is conceptualized to draw information from national s and planning databases and ideally to provide incentives annel young adults to careers of national importance. This preliminary evaluation of an ongoing study.

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