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Bromley, Anthony P.; Boran, James R.; Myddelton, William A.

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ARTICLE

Investigating the baseline skills of research students using a competency-based self-assessment method

ANTHONY P. BROMLEY *University of Leeds, UK*
JAMES R. BORAN *University of Manchester, UK*
WILLIAM A. MYDDELTON *University of London, UK*

ABSTRACT Recent government-led initiatives are changing the nature of the UK PhD to support the greater development of transferable skills. There are similar initiatives internationally. A key requirement and challenge is to effectively assess the 'baseline' skills of a cohort on entry to a research programme and then monitor their progress in personal development. This article describes an innovative methodology that combines competence model and training needs analysis theory to create an effective self-assessment tool: the Development Needs Analysis (DNA), for collection of baseline data. The DNA provides a means for effective self-assessment of skills, and is capable of highlighting particular needs of students grouped by, for example, date of birth and home vs. overseas status. The methodology is broadly applicable in determination of the baseline skills of students and allows practitioners to tailor learning and teaching to the requirements of a cohort.
KEYWORDS: *needs analysis, postgraduate development, self-assessment*

Introduction

> In a modern economy, based increasingly on intellectual capital, greater skills and knowledge are required of the workforce. (Sir Martin Harris, Review of Postgraduate Education, 1996)

The nature of a research degree is changing from the pursuit of a scholarly piece of research focused on specialization within a discipline to a broader-based training ground for skilled researchers who will be able to function in the modern, dynamic workplace. Within the UK, the educational funding bodies began to acknowledge this change during the 1990s based upon feedback from private sector businesses about the work skills of PhD postgraduates (Association of Graduate Recruiters, cited in Harris, 1996). Although postgraduates were highly competent in technical expertise and problem solving, broader skills, such as communication and teamwork, were often found to be lacking.

In the UK this expanded skills agenda developed significantly in relation to research degrees, culminating in the 2002 report of Sir Gareth Roberts (Roberts, 2002). Roberts recommended each research student should have two weeks per year of transferable skills training. Roberts' recommendations were supported with a new UK government funding scheme, acknowledged in a review of research degree programmes (Metcalfe and Green, 2003) and formalized in a revised Quality Assurance Agency Code of Practice for Research Degrees (QAA, 2004). The agenda is not restricted to the UK and is indeed international, illustrated by the Bergen Communiqué (Bergen, 2005) and for example the review similar to the 'Roberts' review carried out in Australia (Australian Government, 2006).

In order to clarify what skills PhD postgraduates might require, the UK Research Councils (RCUK) had produced a Joint Statement on Skills listing 36 critical skills ranging from research management to career development (RCUK, 2001). A number of universities developed skills training schemes, some integrated within degree programmes and others offering an add-on smorgasbord of training courses. However, these skills training initiatives were often implemented without a clear understanding of the effectiveness of different approaches.

A current key debate (Rugby Team, 2006) is how to assess and monitor the effectiveness of these skills development initiatives. In order to monitor progress related to skills development it is critical to know the 'baseline' level in transferable skills of a diverse research student cohort. The questions driving the current study were:

- Can an efficient methodology be developed to obtain a valid 'baseline' assessment of transferable skills in a research student cohort?
- Can differing development needs be identified in the cohort?
- Can the assessment inform the university's development programme?
- Can the methodology be used to monitor progress in personal and professional development?

Building the methodology

These questions are similar to the questions an employer faces when assessing the current skills of their workforce to identify company strengths and to consider additional training needs to improve company performance. Also for consideration is the body of research on assessment in higher education (Dochy et al., 1999; McDowell et al., 2004; Gijbels et al., 2005). However, assessment studies are most generally based on assessment methods in taught programmes rather than the personal and professional development of the individual. The unique approach of this study has been to review literature from the private sector reporting industrial practice in competence models and training needs analysis and apply the best practice to evaluating the effectiveness of skills development for PhD postgraduates in higher education.

There are two main approaches to workforce assessment and development: training needs analysis and competence models. Training needs analysis is seen as having a role in organizational change (Reed and Vakola, 2006) and can vary in scale from a simple survey to a detailed structured process including interviews, observation and focus groups (McClelland, 1993). Training Needs Analysis is commonly described as a three-stage process: organizational analysis, operations analysis and personnel analysis (Moore and Dutton, 1978). A whole-company approach is beyond the scope of this study as there is little opportunity for organizational or operations analysis of the university. However, personnel analysis, which looks at how well each employee is performing the tasks that make up their job, appears to be applicable. Techniques used for determining training needs include: observation – work sampling, interviews, questionnaires and tests (Moore and Dutton, 1978). Within the constraints of this study the self-assessment questionnaire was considered the most viable option.

Historically, in industry, there has been an ethos that the outcome of training needs analysis is training and that performance problems are signs of deficiency. Indeed Gilbert (1967) offers an equation:

$$\text{Deficiency} = \text{Mastery} - \text{Initial Skill Repertory}$$

However, this assumption has changed with Wright and Geroy (1992) pronouncing the demise of the 'needs-analysis-tied-exclusively-to-training' concept. This approach is beneficial in the case of postgraduate skills development because it can account for the wide diversity of the PhD postgraduate population. An experienced, mature PhD candidate may simply need to identify the full range of skills necessary for PhD-quality

research, compare their current skills levels against these target skills and plan their own self-directed development towards improving any deficient skills. This process requires the second method of workforce assessment and development: the competence model.

Competence models are widely used in industry (e.g. in personnel appraisal and development as well as in assessment centres) to improve corporate performance through analysis of the behaviour of individuals (Boak and Coolican, 2001; Boyatzis, 1982; Dalton, 1997). The starting point is for a researcher to carry out a number of 'behavioural event interviews' with individuals (Boyatzis, 1982) and identify specific behaviours that can be related to definitions of 'more effective' and 'less effective' performing individuals. Behaviours are categorized under thematic headings which define the general 'competencies' with associated 'behavioural indicators' which clearly identify the 'level' of the competency required (Boyatzis, 1982). For example, a competency of 'IT proficiency' is open to interpretation: does it mean familiarity with word processing or motherboard reconstruction? Behavioural indicators can clearly specify this. There has also been work that considers 'structural' rather than 'functional' components of a competence, with competencies being considered as consisting of four elements and their relations: technology, people, organizational structure and organizational culture (Drejer, 2001).

In summary, with respect to a methodology for this study, the main elements of personnel assessment and development in industry which could be applicable to postgraduate skills development are competence models and training needs analysis. The present study will propose a unique methodology for dealing with the assessment of skills development and present results from the first year of implementation at the University of Manchester Faculty of Engineering and Physical Sciences (EPS), which has had a skills training programme in place since 1999 (Barber et al., 2000; Barber et al., 2002; Goodison et al., 2003; Bromley et al., 2004; Brunn et al., 2004; Graduate Development Scheme, 2006).

Methods

The development needs analysis

The initial task was to develop a competence model for postgraduates. There was no need to identify the skills needed by PhD researchers from scratch through interviews because the RCUK Joint Skills Statement (JSS) provides a valid list of competencies and had the benefit of already being a recognized standard in postgraduate development. However, more detailed behavioural indicators needed to be developed for each competency. It was considered important to make the behavioural indicators

clearly evidence-based, with specific examples of what type of work would have to be done to illustrate a competence in a given skill. In the interests of simplicity, it was decided to only define one level of each competency: the level that would describe the skill level expected when the researchers had completed their PhD. This level was termed that of 'an experienced PhD student'. Draft statements were generated by the authors and circulated to a panel of academics from the nine disciplines in the EPS Faculty: chemical engineering, chemistry, computer science, earth sciences, electrical engineering, materials, maths, mechanical engineering and physics. The challenge was to create behavioural indicators that were applicable to all disciplines. Of course, an additional benefit of this system could be that specific disciplines could tailor the content of the 'behavioural indicator' to the needs of their discipline, whilst still allowing generic cross-disciplinary data to be collected against the JSS competencies.

A 'skills audit' questionnaire was then developed for all new postgraduates as a form of training needs analysis. This was designed as an online tool using WebCT and asked new researchers to assess their current skills against the competencies and behavioural indicators of 'an experienced PhD student' mentioned above. Students could then rank their own skill level against the indicator on a four point scale: (1) 'good first degree graduate standard'; (2) 'a PhD student with some experience'; (3) 'an experienced PhD student'; and (4) 'a particularly able PhD student'. Thus if the new researcher felt they already had PhD-quality skills in a certain competency, they would give themselves a 'level 3' ranking (or 'Level 4' if they thought they were exceptionally skilled). If they felt they did not meet the Level 3 skill descriptor, they would have to decide, in their own interpretation, whether they were slightly skilled (Level 2) or not skilled at all (Level 1).

In light of the fact that not all training needs analysis need lead to training, the system was termed the Development Needs Analysis. This terminology reflected the variety of learning preferences in a diverse group such as this and acknowledged the importance of researchers designing their own personal development plan, which may or may not include training.

Data analysis

Data were analysed in a number of ways. The overall average score for each question was calculated for comparative purposes. The chi-square (χ^2) goodness of fit test (Zar, 1984) was applied to examine the distribution of scores for each question. The intrinsic hypothesis was that the overall distribution of all scores for all questions represented an average expected level of scoring for new research students which could then be used to generate expected values for the various samples being examined. These

were compared to the specific observed number of each level and the chi-square statistic was calculated using the equation:

$$\chi^2 = \frac{(observed - expected)^2}{expected}$$

Resulting chi-square values were tested for significance for $k-1$ degrees of freedom (where k=the number of score levels) to determine the probability of being able to reject the intrinsic null hypothesis that the distribution of scores for any given subset of data did not vary significantly from the distribution of scores in the overall dataset. Significant differences were identified by minimum probability levels of $p<0.05$, although many differences were significant at $p<0.001$ (Zar, 1984).

The data were also subdivided on the basis of date of birth and home vs. overseas status. The subdivisions were based on the available data recorded in the university student records system. The analyses mentioned above were then carried out on the various subdivisions of the overall dataset.

Results and discussion

Overall

The final Development Needs Analysis (DNA) is presented in Appendix 1. The 36 Research Councils' skills, or competencies, are listed in the left column and the level 3 behavioural indicators associated with each competency are listed in the right column. Each competency is referred to by the letter of the general skills area (e.g. A = Research Skills and Techniques) and a number within that category. A sample screen capture from the online WebCT version of the questionnaire is presented in Figure 1.

The DNA was completed by 201 postgraduate researchers within the first three months of their research programme between October and April 2005. All 36 questions were answered by 187 students (83% of the total number of respondents). The average number of questions answered was 35.2 questions.

The overall dataset of 7067 scores (a range of 195–198 answers per question) is presented in Figure 2. The average for all scores (disregarding blanks) was 1.86, with individual student averages ranging from 1.1 to 4.0 (one student). Figure 2 shows that 64 per cent of students rated themselves above a 'good first degree graduate standard' (i.e. scores of '2', '3' or '4'). This could be due to the fact that many students achieve a Masters degree before beginning a PhD. However, the fact that 81 per cent of all answers were either '1's or '2's (Figure 2) shows a generally low level of scoring suggesting that students understood the basic process of the DNA in that they should not expect themselves to be expert at all PhD skills in the first stages of their research degree.

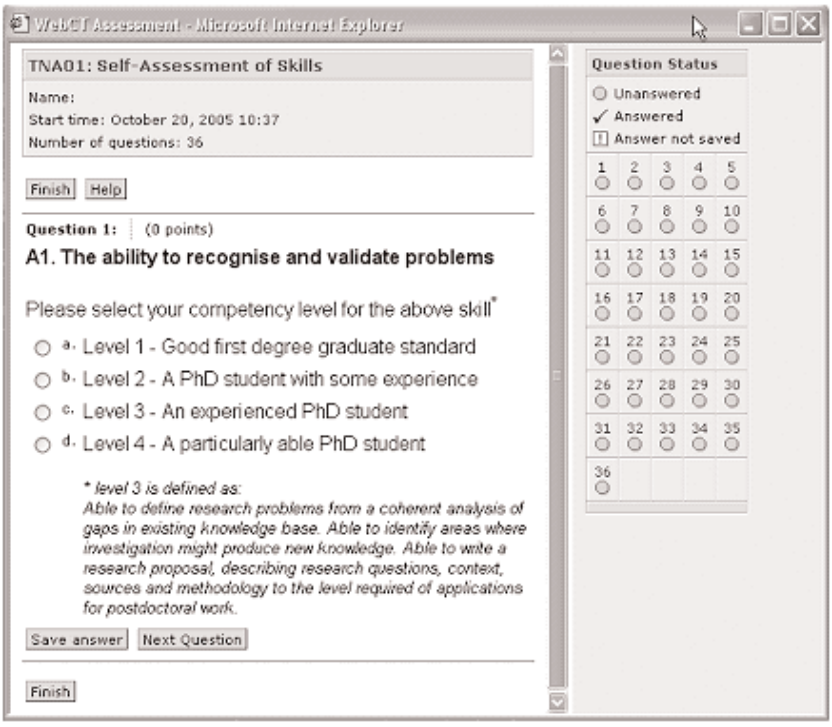

Figure 1 **An example screen shot from the online Development Needs Analysis**

Chi-square analysis found 12 competencies whose rating scores differed significantly from the overall score distribution (Table 1). There were six competencies in which students rated themselves significantly higher than expected from the overall dataset. It is perhaps reassuring that the area students rated themselves most highly in is Health and Safety (JSS B4). In general, students rated themselves most highly in Personal Effectiveness skills (category D: three entries) and in Research Management skills (Category C: two entries). This suggests that PhD students feel they are aware of the personal skills needed, are naturally confident that they have those skills and are highly motivated. There is an absence in the top six skills of categories A (Research Skills and Techniques), E (Communication Skills) or G (Career Management), suggesting that these are the areas in which development programmes should initially focus.

There were six competencies in which students rated themselves significantly lower than expected from the overall dataset (Table 1). They rated themselves weakest in the Communication Skill E3 (defend research outcomes) which is understandable for students at the start of their research programme. There are low rankings for understanding the Research Environment

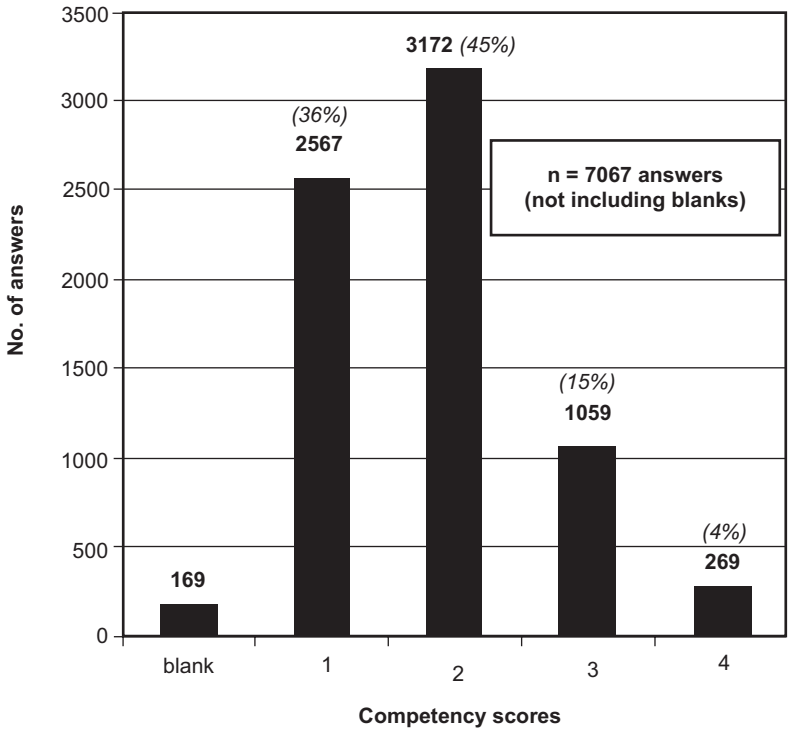

Figure 2 **Distribution of answers to all 36 skills questions from 201 research students**

(category B: three entries) and Research Management (category A: one entry), indicating a lack of awareness from students about the context of their research nationally and internationally.

Date of birth

Date of birth was known for 194 students (Table 2). The group with the highest average rating was one of the older age classes (d.o.b.: 1970–1974; 35–39 yrs old). In fact, the three oldest groups all rated themselves significantly above the average of 1.86. The group with the lowest average rating was one of the younger age classes (d.o.b.: 1981–1982; 24–25 yrs old). This suggests that the older the student the higher their self-assessment rating. This might be expected as older students will have had more opportunity for life experience to develop their transferable skills and perhaps are generally more confident of their skills abilities.

Age does not appear to have a major effect on the rankings of specific skills (Table 2). There were only nine unique skills listed in the 30 top skills (that is, the other 21 skills were duplicated across the six age classes). Only three of

Table 1 **Summary of self-assessed skills for the overall data set: (A) top six skills; (B) bottom six skills**

JSS skill	*Average score*	*Chi-square*	*Significance (df=3)*
(A) Top-rated skills			
B4	2.31	73.06	$p<0.001$
D1	2.24	45.85	$p<0.001$
C4	2.19	35.88	$p<0.001$
D3	2.09	20.06	$p<0.001$
D5	2.08	16.95	$p<0.001$
C3	2.04	12.68	$p<0.01$
(B) Bottom-rated skills			
E3	1.50	41.96	$p<0.001$
B5	1.55	31.46	$p<0.001$
B1	1.57	28.10	$p<0.001$
B7	1.58	28.27	$p<0.001$
E4	1.64	14.22	$p<0.01$
A1	1.69	12.47	$p<0.01$

JSS skill references are defined in Appendix 1

Table 2 **Summary of self-assessed skills by date of birth: (A) top six skills; (B) bottom five skills**

Cohort		*1982/83*	*1981/82*	*1980/81*	*1975–79*	*1970–74*	*1969 or earlier*
Avg. score		1.87	1.66**	1.89	1.90**	2.20**	1.89*
Number in Sample		15	47	50	54	18	10
(A) Top-rated skills							
JSS skills	1st	C4	B4	B4	D1	D5	C4
	2nd	B4	D1	D1	C4	B4	B4
	3rd	D1	D3	C4	B4	A6	D1
	4th	D3	C4	C3	D5	D1	C3
	5th	D2	C3	D3	C3	F2	D3
(B) Bottom-rated skills							
JSS skills	1st	E3	E3	B1	B5	B5	E3
	2nd	A4	B7	B5	B1	B7	B1
	3rd	G2	E4	E3	E3	E3	E2
	4th	G4	B5	B7	B7	B1	E4
	5th	C2	A4	E4	A1	A2	B5

Chi-square significance values for average score values are shown as * = $p<0.05$ and ** = $p<0.001$. JSS skill references are defined in Appendix 1

these skills were different from the list of overall top six skills in Table 1: for the youngest age group (1982/83), D2 (creativity/originality) was unique and for the second to the oldest group (1970–1974), A6 (progress summaries) and F2 (team-working) were unique. This suggests that the greater experience of older researchers has given them more confidence in writing and team-working than the younger researchers, who appear to feel more creative.

There was greater variability for the bottom five self-assessed skills grouped by student date of birth (Table 2). There were 12 unique skills in the 30 skills listed by age in Table 2 and six of these were different from the overall bottom-rated six skills in Table 1. The youngest age class (1982/83) had the greatest differences, with only E3 (research presentation skills) in their bottom-rated skills matching the list for the overall dataset. E3 is also the only skill from Table 1 that appears for all age classes. This is understandable since all students, regardless of age, are just starting out on their research programme and will have had little opportunity for previous experience of this competency.

Two of the unique skills listed by the youngest cohort as needing development are A4 (discipline methodologies) and C2 (library skills). A4 was also listed as a unique bottom-rated skill for the next older cohort, students born in 1981/82. These technical skills are obviously a special concern of these less experienced students. The youngest cohort (1982/83) also was the only cohort to list any skills from the Career Management section (Section G: Appendix 1). This shows a special concern of these younger students for their future careers. Again it may well be expected that more mature students have a better grasp of their career paths.

The final unique skill which appears in the bottom rankings of these age-related self-assessments is A2 (original critical thinking) which is only listed by the older students born in 1970–74. This suggests that, although having greater experience with a team-based, hierarchical workplace, they may not have had the opportunity to develop an awareness of the unique demands for highly independent PhD research.

The specific ranking order of the bottom-rated skills common to all students also varied between some age classes. B5 (understanding funding and evaluation of research) appears in the bottom five for all but the youngest group of students and is the absolutely lowest-ranked skill for two age classes (those born between 1970 and 1979). It is therefore quite clear that few research students have a good understanding of how research is funded at the start of their research programme.

Home and overseas

'Home' or 'overseas' status was only known for 52 of the respondents (Table 3). Overseas students rated themselves, on average, significantly higher than home students.

A comparison of the five top-rated skills of home and overseas students (Table 3) with those for the overall dataset (Table 1) shows little difference. Nine of the 10 skills top-rated for these students occur in the overall listing, suggesting there are no major differences between home and overseas students. The only unique skill listed was for overseas students, who felt more confident of their skills for D7 (show initiative, work independently/be self-reliant).

However, there were differences in the specific rank order of top-rated skills between home and overseas students. Home students ranked D3 (flexibility/open-mindedness) and D5 (self-discipline) in their top-rated skills, whilst overseas students ranked C3 (bibliographic skills) in their top five.

An analysis of the bottom five skills for overseas students (Table 3) is more clearly polarized than any of the other lists discussed previously. Only six of the 10 cells appeared in the overall list of bottom-rated skills (Table 1). Overseas students seemed uniquely concerned about their Career Management (G2, G4) and their knowledge of the Research Environment (B2, and uniquely, B1 and B5 in common with the overall bottom-rated skills). The listing for home students had four of the five bottom-rated skills in common with the overall dataset with the exception of G1 (professional development). This

Table 3 **Summary of self-assessed skills by date of birth: (A) top six skills; (B) bottom five skills**

Cohort		*Home*	*Overseas*
Number in sample		28	24
Avg. score		1.68**	2.05**
(A) Top-rated skills			
JSS skills	1	B4	C4
	2	D1	B4
	3	D5	D1
	4	C4	C3
	5	D3	D7
(B) Bottom-rated skills			
JSS skills	1	E4	B5
	2	E3	G4
	3	B5	B2
	4	G1	B1
	5	B7	G2

Chi-square significance values for average score values are shown as $^{*}=p<0.05$ and $^{**}=p<0.001$. JSS skill references are defined in Appendix 1

may suggest that CPD activity had not been a priority for this group in previous occupations or periods of study.

The ranking order of the bottom-rated skills also varied between home and overseas students. Home students ranked themselves lowest in two skills from category E, Communication Skills (E3 and E4). Interestingly, overseas students gave themselves an average of 2.04 for skill E4 and 1.78 for skill E3, and thus do not appear to consider themselves deficient in communication skills in spite of potential language differences.

Conclusions

The application of competence model theory from private sector workforce assessment and development has proven useful in the context of postgraduate skills development for PhD researchers. The importance of linking behavioural indicators to the competency statements of the UK Research Councils has provided clear, evidence-based guides towards defining the skill requirements for PhD researchers. The design of the Development Needs Analysis appears to give new researchers a starting point in identifying their strengths whilst also providing an insight to skill areas in need of further development to meet the PhD standard.

The data generated by the DNA also demonstrate the efficiency of the methodology in providing an interesting insight into the baseline competence for research students on entry to a PhD programme. The data illustrates that the DNA provides an effective methodology for self-assessment and is able to highlight differences between specific groupings within a student cohort. The strengths and weaknesses of the cohort can be defined and this information can be used to inform subsequent development programmes planned by the institution. By requiring the student cohort to complete the DNA at regular intervals it should be possible to monitor progress in development against the JSS.

Some further exploration is required in the verification of these self-assessments in view of known differences in how people perceive their own abilities and their actual ability levels (Kruger and Dunning, 1999; Ackerman et al., 2002; Dunning et al., 2003; Eva et al., 2004). It would be of interest in future studies to qualify data through interviewing students (Boyatzis, 1982), observing skills such as competence in presentation and applying other skills assessment techniques such as Executive Skills Profile (ESP) (Boyatzis and Kolb, 1995; McClelland, 1993). It would also be of interest to explore links between training programmes, learning styles and personal development (Mainemelis et al., 2002). The Development Needs Analysis was based on generic competencies for all PhDs (RCUK, 2001). Now that the methodology has been established, it would

be interesting to look at competencies created for specific disciplines and locally, working with students and academics in a given university. Within this process the effect on organizational change linked to a specific university could be considered (Reed, 2006) and more in-depth information about individuals completing the DNA could be obtained.

For postgraduate development, self-assessment is only the start of a process which should support student interactions with their supervisor. The supervisor role requires corroboration, feedback and guidance to students in planning their development needs. However, the DNA places the rightful responsibility of initially considering their own competencies with the research students themselves in order to take charge of their own development.

The methodology of combining aspects of training needs analysis with competence models to produce the Development Needs Analysis is applicable broadly to learning and teaching programmes. It is suggested that a well-designed DNA completed by a student cohort at the beginning of any study programme with a significant transferable skills element would be an extremely valuable tool in informing both the students and the 'teacher' about learning needs in comparison to the expected learning outcomes of a given programme. For practitioners, any specified learning outcomes for a learning and teaching activity may be easily expandable to form a Development Needs Analysis. Taking skills-based learning outcomes as desired competencies, with the addition of illustrative 'behavioural indicators' for each competency, may provide a simple self-assessment analysis tool in the first instance. This would be particularly useful as a method for gaining a rapid overview of the skills base of a large cohort when the opportunity for significant one-to-one interaction is limited.

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Appendix 1

The Development Needs Analysis (DNA) used in this study. The section titles and the reference codes (e.g. A1) refer to the JSS (RCUK, 2001) and the abbreviated skills are shortened forms of the full JSS skills. The behavioural indicator describes level 3, an experienced PhD student, on the four point scale described in the methods

Ref	*Abbreviated skill*	*Behavioural indicator (Level 3)*
Research skills and techniques		
A1	Problem solving	Able to define research problems from a coherent analysis of gaps in existing knowledge base. Able to identify areas where investigation might produce new knowledge. Able to write a research proposal, describing research questions, context, sources and methodology to the level required of applications for postdoctoral work.
A2	Original critical thinking	Able to formulate hypotheses and/or research questions for the purposes of designing a personal research project. Able to provide new and innovative research ideas. Able to objectively and knowledgeably criticize published research.
A3	Discipline knowledge	Can communicate knowledgeably about their research topic with supervisor and peers, debating concepts. Familiar with recent relevant literature. Can write a literature review of publication standard on the topic.
A4	Discipline methodologies	Able to discuss and prioritize a range of methodologies to address a research question. Has in-depth knowledge and understanding of appropriate techniques and their application.
A5	Critical literature review	Ability to objectively acknowledge weaknesses and assumptions in one's findings. Ability to apply the same objectivity to the work of others. Good understanding of appropriate methods for testing conjectures or tentative conclusions. Excellent IT ability in data collection analysis and presentation in appropriate graphical form.

(Continued)

Appendix 1 (Continued)

Ref	*Abbreviated skill*	*Behavioural indicator (Level 3)*
A6	Progress summaries	Able to verbally summarize a research problem succinctly to different audiences. Able to objectively criticize own research and define future work. Able to produce written summaries of a variety of lengths to suit the purpose. Able to write progress reports on research of an appropriate professional standard.
Research environment		
B1	Research context	Fairly detailed understanding of how research in a particular field is organized nationally in terms of institutions and centres, congresses, societies, publications, and funding sources and some understanding of these internationally.
B2	Research ethics	Be aware of subject appropriate guidance e.g. 'Safeguarding good scientific practice' – Joint Statement of the Director General of the Research Councils and the Chief Executives of the UK Research Councils 1998. Be aware of university guidelines on copyright and ownership of research.
B3	Good research practice	A good understanding of any relevant university guidelines on research practice (e.g. ethical practice) and any statutory regulatory requirements in your subject area.
B4	Health & safety	Be competent in working with any relevant health and safety regulations.
B5	Research funding	Knowledge of how large and small research projects can be funded, including knowledge of application and evaluation procedures.
B6	Research justification	Have good knowledge of competing techniques and approaches in subject area and their relative strengths and weaknesses.
B7	Commercialization of research	Understanding of both procedures for submission and evaluation of research by journals and publishers and be able to prepare research results for submission. Understanding of the major conferences in the research area. Awareness of university facilities and support for exploitation of research.

(Continued)

Appendix 1 (Continued)

Ref	*Abbreviated skill*	*Behavioural indicator (Level 3)*
Research management		
C1	Project management	Able to make plans and balance competing demands on time effectively. Able to plan, organize, execute and evaluate a research programme. Able to set and prioritize a number of intermediate goals within an individual research project and to develop an effective strategy and timetable for meeting them.
C2	Library skills	Able to collect and record information in an organized and professional way. Competence in relevant software. Able to conduct searches using appropriate online and offline resources.
C3	Bibliography skills	Able to demonstrate an excellent awareness of potential sources of relevant information for subject area. Fluent in referencing appropriate sources and able to use a variety of referencing styles and systems.
C4	IT skills	Able to establish a bibliography at the level expected for scholarly publication and keep it up to date through searches and electronic services. Able to use appropriate software to prepare papers with any relevant special features, such as use of master documents, or embedding of charts, figures and images.
Personal effectiveness		
D1	Willingness to learn	Able to identify and exploit sources of information or instruction on a new area. Excellent attendance at seminars, meetings and conferences.
D2	Creativity/originality	Ability to find solutions to difficult problems. Ability to develop new methodologies as required. Ability to generate new ideas and approaches.
D3	Open-mindedness	Able to analyse the strengths and weaknesses of one's own approach, and willing to complement it by an engagement with other approaches.

(Continued)

Appendix 1 (Continued)

Ref	*Abbreviated skill*	*Behavioural indicator (Level 3)*
D4	Self-assessment skills	Able to evaluate a wide range of skills, evaluate training needs in the light of this and the requirements of the research project, develop a coherent plan for future training.
D5	Self-discipline	Able to work to a professional level without supervision. Able to demonstrate high levels of accuracy, organization and attention to detail.
D6	Awareness of support	Be able to objectively consider gaps in knowledge, understanding or ability and be aware of possible sources of support such as the skills of colleagues.
D7	Self-reliance	Able to make and execute substantial research plans with guidance necessary only for specialist issues.
Communication skills		
E1	Academic writing	Able to produce a well-structured and well written report of substantial length. Able to write concise, academic prose and express ideas with suitable clarity. Full control over a variety of styles.
E2	Critical writing	Able to communicate own research orally and in written reports. Able to explain their research at a range of levels appropriate for e.g. international conference or non-specialist audiences. Able to produce well-constructed clear presentations. Able to use slides, OHPs and PowerPoint confidently and easily in oral presentations. Able to provide feedback for their research subject of the kind expected in referees' reports for journals and publishers and to respond to such feedback.
E3	Research presentation skills	Able to present academic work at seminars and conferences fluently and confidently, and able to respond clearly and persuasively to questions and comments at such occasions.
E4	Promote public understanding	Able to write and present research in an appropriate manner for specialist or lay audiences.

(Continued)

Appendix 1 (*Continued*)

Ref	*Abbreviated skill*	*Behavioural indicator (Level 3)*
E5	Teaching skills	Demonstrate an ability to effectively impart information to others. Have an understanding of possibilities for supporting the learning of others.
Teams/networking		
F1	Networking	Regular attendance at conferences and meetings, awareness of researchers in research field.
F2	Team-working	Can work in teams (e.g. research groups) on complex projects and can both reflect on quality of teamwork and solve team-working problems as they arise.
F3	Feedback skills	Aware of techniques of giving feedback. Aware of others in research group.
Career management		
G1	Professional development	Active member of professional institution. Attending meetings, organizing events, local secretary. Attends seminars and conferences.
G2	Career management	Be aware of potential employers, general recruitment practices and effective job hunting techniques.
G3	Transferable skills	Be aware of potential career paths and the generic aspects of a PhD, including research techniques, project planning and communication skills.
G4	Promote oneself	A broad knowledge of types of CVs, interview techniques and standard questions and techniques such as psychometric testing.

Biographical Notes

ANTHONY BROMLEY is a senior training and development officer within the Graduate Training and Support Centre of the University of Leeds and a Fellow of the Higher Education Academy. He was formerly Graduate Development Manager within the Graduate Development Scheme, University of Manchester. He has broad experience in teaching and learning in higher education and his interests now lie in enhancing the personal and professional development opportunities of graduate students.

Address: Graduate Training and Support Centre, Parkinson Building, University of Leeds, Leeds LS2 9JT, UK. [email: t.p.bromley@adm.leeds.ac.uk]

JAMES BORAN is a graduate development manager at the Graduate Development Scheme, University of Manchester. He has been involved in providing generic skills training to postgraduates since 1999, formerly at the University of Manchester Institute of Science and Technology (UMIST). His interest in postgraduate education arose out of his 20 year research career and associated tutoring and mentoring whilst studying the biology and behaviour of whales and dolphins.

WILLIAM MYDDELTON is an Electronic Resources Officer in the Graduate Development Team. He is experienced in web design, the delivery of online learning materials and quality assurance. Currently, his main work involves the interpretation of traditional paper-based methods in an electronic environment. He is currently working as the Virtual Learning Environment Support Officer at the University of London.