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Individual Differences in Psychology Undergraduates' Development of Research Methods Knowledge and Skills

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Abstract

Not all psychology undergraduates appear to benefit from participating in research methodology classes. This longitudinal study tracked how students' knowledge of research methods developed throughout their three-year undergraduate psychology degree. Card sorting procedures measuring knowledge of research methods terminology were repeated at four time-points across three years then analyzed using multidimensional scaling. There was no significant improvement in students' research methods structural knowledge after a year, but there was by the end of students' second year. Knowledge did not improve after students' final year of study. Various metacognitive and motivational variables were significant correlates of research methods knowledge and research skills. Structural knowledge of research methods terminology appears to be developed from formal methodology training and is not improved upon after completion of a final year research project dissertation. Improving metacognitive skills and increasing motivation for methodology classes may be linked to better development of research methods knowledge and research skills.

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Keywords: Research Methodology Training; Knowledge Development; Motivation.

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1. Introduction

University students are likely to undergo research methodology training while learning how to conduct research, which teaches them about research methods and develops their research skills. In order to develop domain-specific skills, learners need to have knowledge of that domain (Kraiger, Ford, & Salas, 1993).

Research on knowledge development argues that domain knowledge begins with declarative knowledge, which is explicit knowledge about the facts of a domain (Abu-Zaid & Khan, 2013), before developing into procedural knowledge, which is the knowledge or intellectual skills related to knowing how to perform relevant tasks (Davis & Yi, 2004; Gagne, 1984; Rickards, Fajen, Sullivan, & Gillespie, 1997). An example of declarative knowledge of research methods is knowledge of which methodological approaches to use in a given situation. An example of procedural knowledge of research methods is knowing how to apply that methodological approach in that situation. With this knowledge, students can develop research skills.

The mental models of domain knowledge are also important to examine as individual pieces of information gradually become more interconnected throughout learning, transforming into organized knowledge structures of a subject area (Davis & Yi, 2004). Changes in structural knowledge are said to occur as expertise develops (Rowe, Cooke, Hall, & Halgren, 1996). Experts have been found to structure their domain knowledge more efficiently than novices to allow for faster and better access to relevant problem solving information (French & Thomas, 1987; Hong, 1999). Thus, all knowledge types should be considered when exploring the development of proficiency in a domain.

Research has shown that people engaging in a longer period of initial training can recall much of the learned content many years later, even without additional rehearsal of the information (Bahrick & Hall, 1991). However, the process of developing knowledge, as discussed above, does not account for differences in knowledge between students who have all undergone the same length, amount and level of training. Bauer and Bennett (2003) noted how alumni of an undergraduate research programme reported significant improvements in a range of skills and abilities, so there are clear benefits to being involved in research. Bauer and Bennett did not, however, take into account the factors that may have supported or inhibited these improvements in skills and abilities, which vary from student-to-student. Furthermore, while high achieving students have been found to report positive research experiences through continued engagement in research, lower achieving students have reported the opposite (Taraban & Logue, 2012), and many students have professed poor understanding of research methods despite undertaking multiple methodology training courses (Lehti & Lehtinen, 2005). Difficulties with the learning of research methods in psychology has been noted by various research (e.g. Bard, Bieschke, Herbert, & Eberz, 2000) and social science students' difficulties with research methods has been found to be unrelated to their difficulties with the other study areas of their programmes (Murtonen & Lehtinen, 2003). Some students appear to develop knowledge in this domain more readily than others, but it is not clear why. Therefore, individual differences must play a role in this development of knowledge and skills.

1.1. Theoretical Framework

Ackerman (1996) proposed a theory of knowledge acquisition in adult learning called PPIK (intelligence-as-process, personality, interests, and intelligence-as-knowledge) which suggests that the process of knowledge acquisition starts with the cognitive abilities of fluid intelligence (general problem solving ability) and crystallized intelligence (prior knowledge), then takes into account non-ability trait determinants of domain knowledge (such as personality, motivation and interest factors) to explain individual differences in domain knowledge (Ackerman & Beier, 2006). Thompson and Zamboanga (2004) found that prior knowledge has an effect on course achievement independently of cognitive ability or engagement. Therefore, as individuals increase their knowledge of a domain through learning, it would be logical to assume that these cognitive and non-ability factors act as facilitators and barriers to the development of knowledge and expertise.

Since knowledge is domain-specific (Rolfhus & Ackerman, 1999), the factors involved in development of knowledge in one domain might not be the same for another domain. Murtonen (2005) noted that motivation, approaches to learning and metacognitive skills are likely to play a part in students' learning of quantitative methods, and that anxiety about this learning would likely impact on students' motivation to learn. Research has also been conducted on the impact of maths, statistics and research anxiety on statistics achievement (Bandalos, Finney, & Geske, 2003; Onwuegbuzie, 1997, 2003; Townsend, Moore, Tuck, & Wilton, 1998), rather than on research methods knowledge and research skills in general. The relationship between research self-efficacy and research interest has also been examined in doctoral students undertaking research as part of counselling programme (Bieschke, 2006; Bishop & Bieschke, 1998), but no similar research has been conducted with undergraduates. It is still not clear how or if cognitive ability, prior knowledge and non-ability factors actually directly relate to the development of research methods knowledge and research skills.

1.2. Rationale, Aims and Research Questions

Murtonen (2005) noted that much research has focused on problems with learning statistics and very few studies focus on developing research skills, so she broadened her focus to include learning of quantitative research methods. The current study broadens the focus even further to encompass research methods learning and research skills in general, whether quantitative or qualitative. This is of particular importance considering that Murtonen envisioned students would have similar problems when learning research skills as a whole, to the problems that students have with learning statistics. Furthermore, differences in motivation, approaches to learning, metacognitive skills and anxiety are assumed to be related to research methods learning, but it is not clear whether these factors are merely related to inclination to learn, or whether they actually have a direct role in the development of research methods knowledge and research skills as well. To date, no studies have considered the role of a range of psychological constructs in the development of research methods knowledge and research skills.

The aims of the current study were to see how students' structural knowledge of research methods develops over time and to ascertain the factors that may account for this development and the formation of declarative and procedural knowledge, and research skills. The following research questions were addressed by the current study:

- How do experts and students structure their knowledge of research methods?
- Does students' structural knowledge of research methods become more similar to experts throughout their degree?
- Can differences in research methods knowledge and research skills be explained by individual differences in cognitive ability, prior knowledge, non-ability traits, and amount of deliberate practice of research methods engaged in?

2. Method

2.1. Design

A longitudinal design was used to determine the development of research methods knowledge by undergraduate psychology students across their degree. Structural knowledge of research methods was assessed at the beginning of the students' degree (T1), then again at the end of their first year (T2), second year (T3) and third (final) year (T4) of study.

2.2. Participants

The total sample consisted of 259 undergraduate psychology students from a single cohort (205 females, 54 males, M_{age} = 20.56 years, SD_{age} = 4.60, age range: 18–47 years at the commencement of the current study) studying at a post-1992 London-based university. The sample size incorporates all participants that took part in any aspect of the study. Not all participants chose to participate in all stages of the study.

2.3. Materials

2.3.1. Cognitive ability measure

Fluid intelligence (G*f*; intelligence as general problem solving ability) was measured by the Raven's Advanced Progressive Matrices (APM) test (Raven, Raven, & Court, 1998).

2.3.2. Psychometric measures

In addition to a demographic questionnaire, a battery of self-report questionnaires was administered to assess individual differences on the basis of various non-intellective psychological factors. The constructs chosen to be measured in the current study were selected on the basis of a recent meta-analysis of non-intellective psychological factors predicting general academic performance by Richardson et al. (2012). A variety of constructs involving students' approaches to research (Bard et al., 2000; Onwuegbuzie, 2003) were also measured as these were felt to be relevant to the knowledge domain being examined in the current study.

The following measures were used: *Conscientiousness* subscale of the *Five-Factor Inventory (NEO-FFI)* (Costa & McCrae, 1992); *Academic Procrastination* subscale of the *Procrastination Assessment Scale for Students (PASS)* (Solomon & Rothblum, 1984); six subscales of the *Motivated Strategies for Learning Questionnaire (MSLQ)* (Pintrich & de Groot, 1990) including *Performance Self-Efficacy*, *Test anxiety*, *Elaboration*, *Metacognitive Self-Regulation*, *Effort regulation* and *Time/study environment management*; *Academic Self-Concept Scale* (Reynolds, 1988); *Attentional Control Scale* (Derryberry & Reed, 2002); *Surface Learning* and *Strategic Learning* subscales of the *Approaches and Study Skills Inventory for Students – Short Version* (Entwistle & Ramsden, 1983); *Perceived Stress Scale* (Cohen, Kamarck, & Mermelstein, 1983); *Academic Stress Scale* (Abouserie, 1994); *Trait Anxiety* subscale of the *State-Trait Anxiety Inventory (STAI)* (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983); *Interest in Research Questionnaire (IRQ)* (Bishop & Bieschke, 1998); *Research Self-Efficacy Scale (RSES)* (Bieschke, Bishop, & Garcia, 1996; Greeley et al., 1989); *Research Anxiety Rating Scale* (Onwuegbuzie, 1996); *Statistics Anxiety Rating Scale (STARS)* (Cruise & Wilkins, 1980).

2.3.3. Deliberate practice of research methods

Throughout their first year of study, students were provided with 29 optional workshop exercises for their research methods course. These were made available on their virtual learning environment (Moodle) and covered topics relating to various quantitative and qualitative research methods. The proportion of the workshop exercises that were completed was used as a proxy of the amount of deliberate practice of research methods engaged in.

2.3.4. Knowledge measures

Average marks from two *research methods multiple-choice tests* were used to represent declarative/procedural knowledge of research methods. Average marks from two *research reports* were used to represent procedural knowledge of research methods and research skills. A *numeracy/statistics pre-test* taken in the first week of term was used to represent prior declarative knowledge of numeracy and statistics prior to starting methodology training.

In order to evaluate structural knowledge of research methods, a card sort was developed for the current study. Card sorting procedures are a reliable technique for obtaining cognitive representations of an individual's knowledge of a specific domain (Harper et al., 2003). Key aspects of research methods were deemed to include knowledge of research methods terminology, so 26 items were produced that covered terms from the different research domains taught in the methodology courses on the undergraduate psychology programme of the sampled university (i.e. descriptives, hypothesis testing, correlational design, psychometrics, qualitative research and experimental design). The items contained within the card sort were verified by two experts (academic staff members) to ensure that they covered the appropriate breadth of knowledge expected to be developed at this level. An expert group was also recruited to create a referent knowledge structure against which the students' structures were based. This group consisted of five research methods instructors who had experience of conducting research at doctoral and post-doctoral level.

2.4. Procedure

Data was collected over the course of three academic years. At the beginning of students' first year, participants were asked to complete the demographic questionnaire followed by the card sorting task in their induction week (T1). The card sorting task could then be used as a baseline measure of participants' structural knowledge of research methods. Participants were provided with virtual cards displayed in a random order listing each of the research methods terminology items. Participants were instructed to sort these cards into 'piles' based on common groupings of perceived shared meaning between the items. Following this were five further separate data collection sessions across the students' first academic year, in which participants completed the above measures. These sessions included the same participants if they were present in those sessions. At the end of the academic year, participants were asked to complete the same card sort again (T2). The same cohort was then contacted again to complete the card sort at the end of their second year of study (T3) and the end of their final year of study (T4).

3. Results

3.1. Card sort data coding

Card sort data was entered into distance matrices that displayed the perceived dissimilarities between each of the items for each participant in the form of raw proximity scores between each pair of items (0 = similar, 1 = dissimilar). In order to determine how much knowledge was being exhibited by participants, all participants' card sort data was compared to a group of experts' card sort data, which was used as a referent structure.

3.2. Group level knowledge

Composites of all card sort data were formed for all participants that took part at each time-point. The referent expert matrix and the composite distance matrices for all participants at T1, T2, T3 and T4 were then separately submitted to Kruskal's (1964) non-metric multidimensional scaling (NMDS) procedures with ordinal transformations using the PROXSCAL procedure on SPSS. As part of the MDS analyses, cognitive maps are produced, which are visual representations of participants' structural knowledge of a domain and can be produced for an individual or for groups of individuals (Goldsmith, Johnson, & Acton, 1991; Gonzalvo, Cañas, & Bajo, 1994). The maps are used to identify how participants have grouped items they feel are related (i.e. clusters of items will form where participants feel that these items are related) and also to reveal the underlying dimensions in the data (i.e. the spacing between items and clusters along each dimension should elucidate how the participants believe the items are related along two continuums). Figure 1 displays the expert knowledge structure cognitive map.

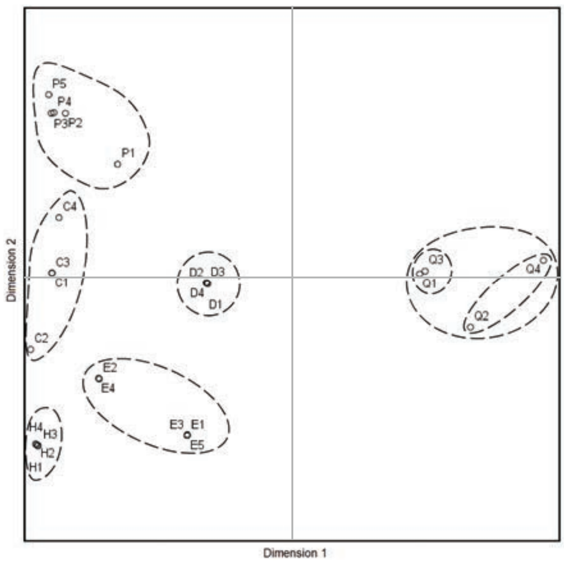

Fig. 1. Referent Expert Knowledge Structure Cognitive Map. D = Descriptives items, H = Hypothesis Testing items, C = Correlational Design items, P = Psychometrics items, Q = Qualitative Research items, E = Experimental Design items. *STRESS-1* = .03, *D.A.F.* = .9994, *T.C.C.* = .9997, *n* = 5.

As expected, the expert knowledge structure (Figure 1) appears to show clusters of items grouped together on the basis of the different research domains that form part of the undergraduate psychology programme and were part of the design of the original card sort. These have been indicated in Figure 1 by the dashed loops. The qualitative items can also further be distinguished by being sub-divided into discourse and content-based approaches. As can also be seen in Figure 1, the qualitative items cluster towards the positive pole of dimension 1 (to the right of the vertical line), whereas all other items tend to cluster towards the negative pole. Therefore, dimension 1 was labelled as *Quantitative/Qualitative Research*. There appeared to be far more subtle distinctions between clusters along dimension 2. The qualitative and descriptive statistics items sit in the middle of this dimension. To the positive end of the pole (above the horizontal line) are correlational design items, with psychometric items at the far end. At the end of the negative pole are hypothesis testing and experimental design items. Items at the negative pole tend to focus more on hypothesis testing research whereas items at the positive pole tend to focus on hypothesis generating research. Therefore, dimension 2 was labelled as *Hypothesis Generating/Hypothesis Testing Research*.

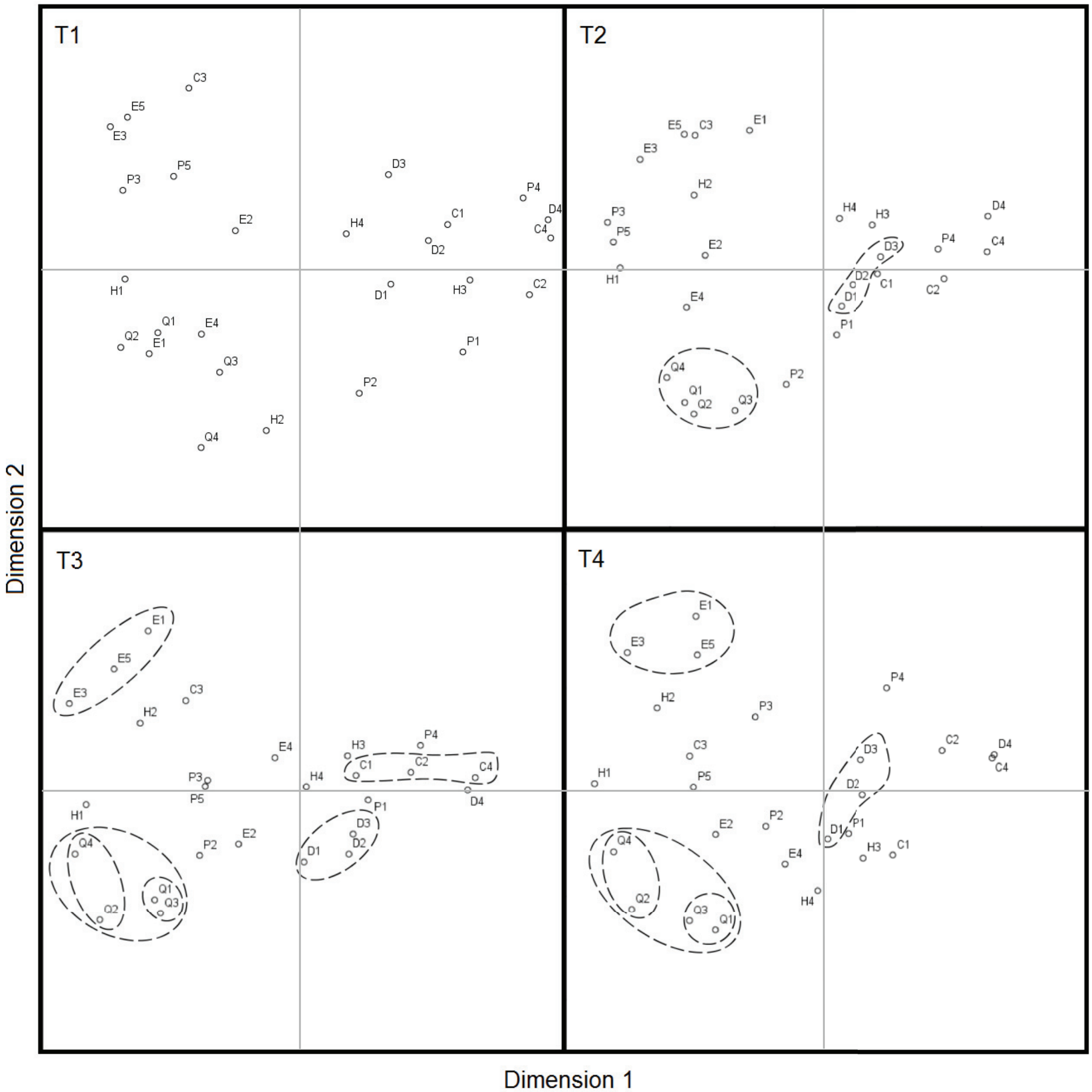

Fig 2. Research Methods Terminology Group Level Knowledge Structure Cognitive Maps at T1, T2, T3 and T4. T1: *STRESS-1* = .15, *D.A.F.* = .98, *T.C.C.* = .99, *n* = 178; T2: *STRESS-1* = .14, *D.A.F.* = .98, *T.C.C.* = .99, *n* = 95; T3: *STRESS-1* = .16, *D.A.F.* = .98, *T.C.C.* = .99, *n* = 189; T4: *STRESS-1* = .18, *D.A.F.* = .97, *T.C.C.* = .98, *n* = 71.

Figure 2 displays the knowledge structure cognitive maps of all participants at T1, T2, T3 and T4. Looking at the T1 research methods terminology knowledge structure, which represents students' structural knowledge prior to commencing methodology training, there does not appear to be any particular coherence between the groupings of items. Unlike the expert structure, items appear to be scattered with very few related items being closely aligned. The positions of the items do not fit with the dimensions defined in the referent expert structure and the lack of a coherent structure makes it difficult to extract any meaningful dimensions, thus demonstrating no discernible understanding of research methods terminology. At T2, while many of the items remain in similar positions to T1, the items are far less spread out and scattered. The most notable improvement is the distinct cluster of qualitative items that has formed. At T3, the structure does appear to be more similar to the experts' structure with items being far less dispersed. Some slightly larger groupings of correctly related items have formed. Most notably, qualitative items are still grouped together and can now be further distinguished by being sub-divided into discourse and content-based approaches like the experts' structure did. At T4, the structure remains largely the same as at T3 with groupings being similar. However, some groupings are less clearly delineated from other items than at T3. While the qualitative items are not as clearly delineated from the quantitative items as with the expert group, it does appear that the dimension of *Quantitative/Qualitative Research* is being somewhat demonstrated by participants at T2, T3 and T4 (this is along dimension 2 for the students instead of dimension 1 as it was for the expert group, but the dimension numbering is arbitrary as the two-dimensional space can be rotated). There is, however, nothing to suggest that the other dimension is being considered in terms of *Hypothesis Generating/Hypothesis Testing Research* or anything else.

3.3. Formation of knowledge indexes

In order to determine how much knowledge was being exhibited by individual participants, each participant's card sort data was compared to the experts' card sort data at a more direct level to produce a quantitative index of student-expert knowledge similarity. A series of weighted non-metric multidimensional scaling (WMDS) procedures were performed. WMDS can be used to determine the similarity between card sorts by examining multiple matrices as part of the same analysis (Carroll & Chang, 1970; Kruskal & Wish, 1978; Schiffman, Reynolds, & Young, 1981). For each individual card sort at T1, T2, T3 and T4, the individual distance matrices were analysed with WMDS alongside each referent expert matrix. Once each distance matrix had been analysed using the WMDS procedure, Euclidean distances were obtained which represented the proximities of all pairs of items in the two-dimensional space for each card sort. In order to form an index of knowledge for all participants, the distances from each participant's map were correlated with the expert distances. Fit statistics for each of the individual WMDS solutions were found to be optimal in the ranges of: *STRESS-1* = .01 - .05, *D.A.F.* = .998 - 1.000, *T.C.C.* = .999 - 1.000. Correlations of the distances had the potential to range from -1 to +1 with values closer to +1 (i.e. distances more strongly correlated) indicating higher similarity to the expert structure.

3.4. Structural knowledge development from T1 to T4

To determine whether students' knowledge improved across their degree relative to their starting amount of knowledge, differences in the mean knowledge index scores were compared to T1 (baseline knowledge) at T2, T3 and T4. Indexes were compared to T1 separately using *t*-tests rather than across all time-points in the same analysis, as the sum of all knowledge demonstrated by each time-point was the focus of the current study. Structural knowledge did not differ significantly from T1 (M = .59) to T2 (M = .56), and there was no effect, $t(70) = .70$, p = .489, d = .11. There was, however, a significant improvement in structural knowledge of research methods terminology from T1 (M = .57) to T3 (M = .66) and this difference had a small effect size, $t(120) = .70$, $p = .028$, d = -.29. At T4, structural knowledge seemed to reduce again (M = .63) and was not significantly different to T1 (M = .57) or showing an effect, $t(57) = -.91$, $p = .365$, $d = -.18$.

3.5. Individual differences

To determine the variables that were useful predictors of knowledge, all individual difference factors were correlated with knowledge measures. For the structural knowledge indexes, only the T2 indexes were used at this stage as this time-point was at the end of the students' first year and all individual difference measures were administered in the first year. Structural knowledge change indexes were also formed by taking the values for structural knowledge indexes at T2 and subtracting T1 index values to determine how much knowledge had changed between the two time-points.

Structural knowledge indexes were significantly positively correlated with performance self-efficacy ($r = .33$, p = .009), research self-efficacy ($r = .27$, $p = .037$), metacognitive self-regulation ($r = .31$, p = .014), effort regulation (r = .31, $p = .014$), attentional control ($r = .25$, $p = .027$), interest in research ($r = .27$, $p = .037$) and deliberate practice of research methods ($r = .23$, $p = .026$). In terms of knowledge change, a larger increase in structural knowledge from T1 to T2 was also positively correlated with metacognitive self-regulation (r = .27, p = .05) and deliberate practice of research methods (r = .24, p = .047), but was additionally significantly positively correlated with time and study environment (r = .36, p = .007), elaboration (r =.32, p = .021), conscientiousness (r = .37, p = .005), and strategic learning (r = .37, p = .006). For declarative/procedural knowledge and research skills measures, deliberate practice of research methods and prior declarative knowledge of numeracy/statistics were significantly positively correlated with both the multiple-choice tests (rs = .50 and .57, respectively, both ps < .001) and research reports measures (rs = .41 and .24, respectively, both ps < .001). Multiple-choice tests were significantly negatively correlated with trait anxiety (r = -.18, p = .021), statistics anxiety (r = -.32, p = .001), research anxiety (r = -.26, p = .005), academic stress (r = -.17, p = .028), academic procrastination (r = -.20, p = .01), and perceived stress (r = -.20, p = .011), and significantly positively correlated with academic self-concept (r = .17, p = .033), and cognitive ability (r = .38, p < .001).

4. Discussion

4.1. Experts' and Students' Knowledge Structures

Group level knowledge structure cognitive maps showed that experts formed clear groupings of relevant items along two clear dimensions, which supports Davis and Yi's (2004) claim that experts form organized knowledge structures of a subject area. While students' structural knowledge became visually closer to that exhibited by experts, there were still key differences. Students appeared to distinguish between quantitative and qualitative research terms by the end of their first year, but they did not see research in terms of hypothesis testing or hypothesis generating at any stage. This is potentially due to the structure of methodology training at the sampled university, in which methodology modules are separated into quantitative and qualitative research methods. Students distinguished between the different types of qualitative methods after being taught these in their second year and they were able to distinguish some research domain clusters, but by the end of their degree some of these groupings no longer existed or the items were less tightly clustered, indicating a decline in knowledge during this final year of study.

4.2. Development of Structural Knowledge

Structural knowledge did not significantly change by the end of students' first year, but there were significant improvements in knowledge by the end of their second year. However, no significant difference was found in the structural knowledge held at the beginning of students' degrees to the end of their degrees (and no effect was indicated). While students presumably do not lose all of the knowledge they formed in their first two years of study, this does imply that once methodology training ends (in the participants' case, at the end of their second year of study), any structural knowledge of research methods terminology is not maintained. This is even after completing an empirical research project. Since people can retain knowledge many years after learning it if the initial period of training is long enough (Bahrick & Hall, 1991), the current findings indicate that the two-year period of methodology training for students was not a sufficient length of time for the majority of participants to retain knowledge that was significantly different from their starting amount.

4.3. The Role of Individual Differences

Self-regulatory and motivational constructs were found to be related to higher structural knowledge and development of structural knowledge. This substantiates Murtonen's (2005) assumption that these factors might be involved in the learning of research methods, and demonstrates that these factors go beyond the learning of quantitative methods alone. Furthermore, since structural knowledge is implicated in the development of expertise, as discussed above, this also demonstrates that these constructs are likely to be a part of developing proficiency in research at undergraduate level. Prior knowledge was related to the development of various types of knowledge, although this was less of a factor when taking into account deliberate practice of research methods, which was the largest predictor of knowledge and skills in general. Since research self-efficacy and research interest were significantly positively correlated with knowledge, this shows that these factors should be considered with undergraduates rather than just postgraduates, as has previously been done (Bieschke, 2006; Bishop & Bieschke, 1998), and that both statistics and research anxiety relate to research methods learning in general, not just achievement in statistics or quantitative methods courses (Bandalos et al., 2003; Murtonen, 2005; Onwuegbuzie, 1997, 2003; Townsend et al., 1998).

4.4. Limitations, Implications and Future Research

It is not clear whether the individual differences measured preceded the knowledge being developed. If there is a causal link between factors, it is possible that an increase in knowledge resulted in a change in the individual difference factors rather than the other way around. Future longitudinal research may benefit from re-administering some of the state-based psychometric measures at later stages to determine changes in these psychological constructs and potential for different directional relationships with knowledge. Although a causal link is not certain, it may be beneficial for students to be encouraged to use certain strategies through learning interventions and determine whether these strategies impact subsequent research methods knowledge and research skills. This could involve more engagement with practice activities, trying to increase interest in research, and training in the use of certain metacognitive self-regulated learning strategies. Furthermore, reducing anxiety while increasing self-efficacy may be beneficial. Finally, while this study focuses on cognitive and motivational aspects of knowledge development in research methods, students' conceptions of research must also be considered, as without a thorough understanding of the beliefs students hold about this learning, students may not have the inclination to learn the subject or make use of beneficial strategies.

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