Original Article

Measuring Adaptive Expertise in Radiology Residents: A Multicenter Study

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ABSTRACT

Introduction: Adaptive expertise is the ability of individuals to create innovative solutions when they come across novel problems or workplace challenges. Clinicians are often adept at handling routine clinical procedures but lack confidence and a proper strategy when previously un-encountered situations arise. Lots of research has been conducted on basic concepts and development of adaptive expertise however major chunk of literature belongs to non- medical fields. Little is studied about assessment of adaptive expertise in medical professionals and postgraduate residents.

Objective: To measure adaptive expertise (AE) of radiology residents and to assess any association between the AE of postgraduate radiology residents (PGR) and their years of training.

Methods: This multicenter correlational study involved 181 radiology residents from nine major teaching hospital of Lahore, Pakistan from May to October 2019. Katerina Bohle Carbonell Adaptive Expertise Inventory was used as a data collection tool. The questionnaire contained a total of eleven items encompassing two dimensions of AE: domain-specific and innovative skills. Total scores representing AE of PGRs were measured. AE scores and years of training were correlated using Spearman rho correlation. One-way ANOVA was conducted to further evaluate the association between AE and years of postgraduate training.

Results: Out of 181 residents there were 78 (43.1%) males and 103 (56.9%) females. Most of them, 97 (53.6%) were enrolled in four years fellowship (FCPS) program and 62 (34.3%) were in the first year of their residency. Total AE scores of all radiology residents ranged from 33 to 54. AE scores and years of residency were positively correlated ($r_s = 0.4$, $p < 0.01$). One-way ANOVA and Post hoc comparisons using Tukey HSD test further revealed significant pairwise differences between mean scores of residents' groups ($p = < 0.05$) rejecting the null hypothesis

Conclusion: Overall, this study concludes that residents acquire adaptive expertise perpetually with progression in their training.

KEYWORDS: Adaptive Expertise (AE), Radiology, Postgraduate Residents (PGRs)

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INTRODUCTION

The complex and constantly evolving landscape of medical technology has created an ever-widening gap between knowledge and skill (Cutrer et al., 2017). This presents a challenge for medical professionals to keep themselves abreast with the latest developments in the field of medical technology (Cutrer et al., 2017). Furthermore, this places a responsibility on medical educationists to foster AE in medical students and residents right from the start of their training, not only to bring efficiency in their everyday tasks but also to encourage innovation for tackling non-routine or challenging problems.

In medical education, adaptive expertise is defined as the ability of individuals to create innovative solutions when they come across novel problems or workplace challenges (Mylopoulos & Regehr, 2009). Developing AE in PGRs is of utmost importance to ensure that they can provide the best possible care for their patients through innovative problem-solving skills (Mylopoulos, Regehr, & Ginsburg, 2011).

The theoretical framework of AE was first introduced by Giyoo Hatano and Kayoko Inagaki in 1986 (Hatano & Inagaki, 1986). They demarcated expertise into two subtypes: routine and adaptive expertise with the latter having additional facets of flexibility and innovation (Mylopoulos et al., 2011). The two dimensions of AE are efficiency and innovation (Fig. 1). The horizontal dimension is efficiency which describes the phenomenon that any medical professional performing a task repeatedly, accurately, and with speed becomes proficient in that particular task over time. The vertical dimension is the innovation which is a quality that emerges when clinicians encounter situations when previously practiced routine expertise will not be applicable (Schwartz, Bransford, & Sears, 2005).

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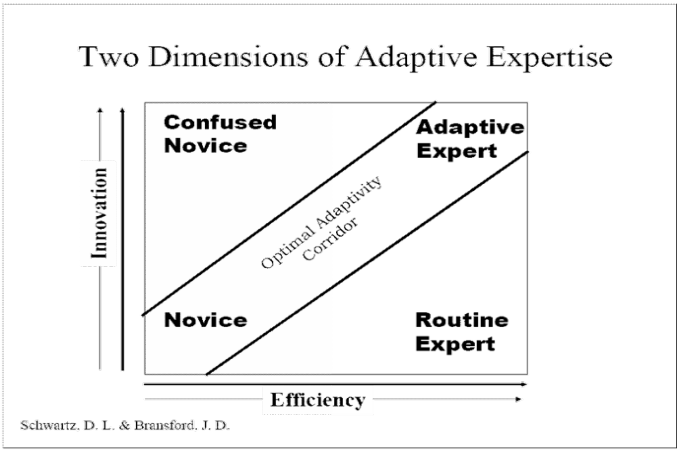


Fig. 1 Relationship of Innovation and Efficiency

Literature reveals that our clinicians are not learning effectively during practice to get prepared for future workplace challenges (Cutrer et al., 2017; Mylopoulos, Brydges, Woods, Manzone, & Schwartz, 2016; Mylopoulos, Kulasegaram, & Woods, 2018). Furthermore, medical stakeholders lack knowledge regarding the effectiveness of the medical curriculum and training system in fostering AE in their postgraduate residents. As a consequence of these two factors combined, clinicians are often adept at handling routine clinical procedures but lack confidence and a proper strategy when previously un-encountered situations arise.

Plenty of research has been conducted on basic concepts and development of AE. (Lajoie & Gube, 2018; Mylopoulos et al., 2018; Pusic et al., 2018; Quirk & Chumley, 2018) (Lajoie, Gube, Lajoie, &Gube, 2018), (Mylopoulos et al., 2018), (Pusic et al., 2018), (Quirk, Chumley, Quirk, & Chumley, 2018), (Kellman&Krasne, 2018), however, a significant proportion of the published literature measuring AE comes from non-medical fields (Ferguson et al., 2018; Fisher & Peterson, 2001; Martin, Rivale, & Diller, 2007). The goal of this study is to use a validated instrument for measuring the AE of radiology residents who require excellence for dealing with routine and non-routine tasks encompassing a plethora of modalities such as ultrasound, computed tomography, magnetic resonance imaging, fluoroscopy, guided interventions, etc. Moreover, this study intends to help the medical institutions to set goals and to train postgraduates strategically and effectively in line with the future demands of adaptive experts.

METHODS

This correlational and multicenter study targeted all major public and private teaching hospitals of Lahore offering postgraduate degrees in radiology. The ethical approval was taken from the Advance Study Research Board and the Ethical Committee of the University of Lahore. A target sample size of 181 was established with a 97% confidence interval using OpenEpi calculator. Convenience sampling was done for the target population of PGRs doing training in these hospitals. Both male and female PGRs in their 1st-5th year of training and those who had just completed their training but did not appear in exams yet were included in the study. The sample included PGRs from four main types of postgraduate residency programs such as Fellowship of the College of Physicians and Surgeons (FCPS), Membership of the College of Physicians and Surgeons (MCPS), Diploma in Medical and Diagnostic Radiology (DMRD) and Doctor of Medicine (MD). Validated Adaptive Expertise Inventory (Cronbach alpha 0.85) was used in this study (Carbonell, Könings, Segers, & Merriënboer, 2015) after taking permission from the author. This instrument focuses on two domains of AE; domain-specific and innovative skills (Carbonell et al., 2015). The questionnaire contains eleven items measured on a 5-point Likert scale (never, rarely, sometimes, often, and very often). After rephrasing the questionnaire, it was piloted with ten PGRs for clarity. Data were collected from May to October 2019 from residents training in nine teaching hospitals of Lahore after taking their consent. Two methods were used for data collection; E-mail and in person by researcher after receiving permission from head/ senior consultant of radiology departments. The author explained the concept of AE and then asked the residents to fill the questionnaire to maintain the homogeneity in data collection.

The data of our questionnaire comprising of a total of fifteen questions (4 demographic and 11 related to AE) was assembled. The acquired data were analyzed in SPSS-25 and statistical tests were conducted. Frequencies and percentages of the first four questions related to gender, training program, hospital attached and year of residency were determined. Frequencies and percentages of responses to all eleven questions related to AE were calculated. Total scores representing the AE of the postgraduate radiology residents were measured from the sum of ratings given to each item. For the distribution of data, Shapiro-Wilk's test ($p > 0.05$) was applied. AE scores and years of training were correlated using Spearman rho Correlation. One way ANOVA and post hoc analysis was conducted to further evaluate the null hypothesis that there is no association between adaptive expertise and year of postgraduate training. The relationship of AE with gender and residency program was also plotted.

RESULTS

Out of 181 PGRs, 78 (43.1%) were males and 103 (56.9%) were females. 97 (53.6%) of the participants were enrolled in four years fellowship (FCPS) program and 62 (34.3%) were in the first year of their residency (Table 1). Most students opted for either often or very often choices (Table 2), achieving an AE score that ranged from 33 to 44. A Shapiro-Wilk's test ($p > 0.05$) and visual inspection of their histograms, Q-Q plots, and box plots showed that the AE scores were approximately normally distributed for years of radiology residency. For the second objective of this study, AE scores were correlated with years of residency. Spearman's rho correlation ($r_s = 0.4$, $p < 0.01$) exhibited positively correlated AE scores and years of residency (Table 3). There was only a slight difference in AE scores of females and males with females getting a score of 0.58 higher than males. No significant relationship was established between total AE scores and residency programs ($p > 0.05$). One way ANOVA was conducted to evaluate the null hypothesis that there is no association between adaptive expertise and a year of postgraduate training (N=181). The independent variable, year

of residency included six groups: 1st year (M = 41.41, SD = 4.05, n = 62), 2nd year (M = 43.32, SD = 4.67, n = 49), 3rd year (M = 44.26, SD = 4.69, n = 34), 4th year (M = 46.00, SD = 3.50, n = 25), 5th year (M = 46.00 , SD = 2.64, n = 3), completed, (M = 48.62, SD = 4.50, n = 8). The assumption of homogeneity of variance was tested and found tenable using Levene's test, F(5, 175) = 1.30, p = .26. The ANOVA was also significant F(5, 175) = 7.32, p = 0.00. So there was significant support to reject the null hypothesis and conclude adaptive expertise increases as radiology residents' progress in their year of training. Post hoc comparisons using Tukey HSD test revealed significant pairwise differences between mean scores of 1st year and senior residents of 2nd,3rd,4th year and who have completed training (p = < 0.05) rejecting the null hypothesis (Graph 1).

Table I: Demographic Data

Demographic	Frequency	Percent
Gender		
Male	78	43.1
Female	103	56.9
Total	181	100.0
Residency program		
FCPS	97	53.6
MCPS	9	5.0
DMRD	53	29.3
MD	22	12.2
Total	181	100.0
Year of Training		
1st Year	62	34.3
2nd Year	49	27.1
3rd Year	34	18.8
4th Year	25	13.8
Fifth Year	3	1.7
Completed	8	4.4
Total	181	100.0
Hospital Attached		
Hospital 1	32	17.7
Hospital 2	21	11.6
Hospital 3	34	18.8
Hospital 4	20	11.0
Hospital 5	16	8.8
Hospital 6	15	8.3
Hospital 7	12	6.6
Hospital 8	17	9.4
Hospital 9	14	7.7
Total	181	100.0

FCPS: Fellow of college of physicians and surgeons of Pakistan, MCPS: Member of college of physicians and surgeons of Pakistan, DMRD: Diploma in Medical Radio Diagnosis, MD: Doctor of medicine.

Table II: Frequencies of Questionnaire Items

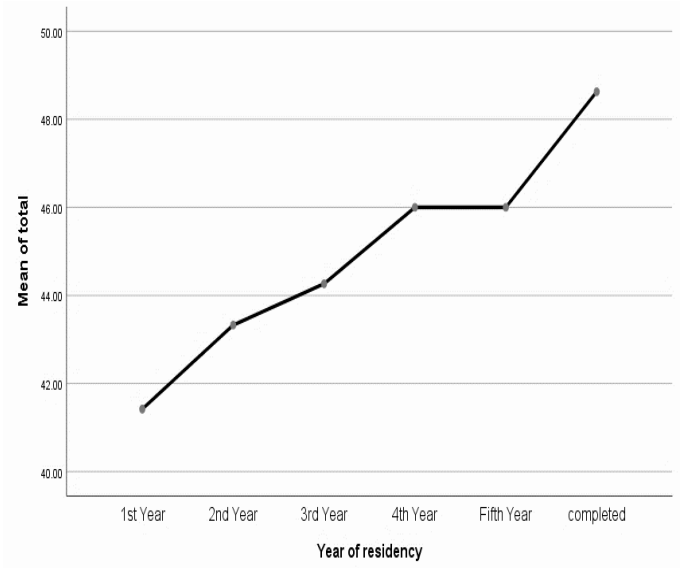
#.	Question	Never N (%)	Rarely N (%)	Some-times N (%)	Often N (%)	Very often N (%)	Mean	Standard deviation
Domain-Specific Skills								
1	During residency, I was able to develop and integrate new knowledge with what I learned in the past.	0 (0 %)	5 (2.8 %)	30 (16.6%)	86 (47.5 %)	60 (33.1 %)	4.11	.774
2	During residency, I concerned myself with the latest development in the domain of my discipline.	1 (0.6 %)	9 (5.0 %)	49 (27.1%)	86 (48.6%)	34 (18.8%)	3.80	.819
3	During residency, I gained a better understanding of concepts in my discipline.	0 (0%)	4 (2.2%)	20 (11.0 %)	109 (60.2%)	48 (26.5%)	4.11	.674
4	During residency, I realized that the knowledge in my discipline keeps on developing.	0 (0%)	5 (2.8 %)	14 (7.7 %)	72 (39.8 %)	90 (49.7 %)	4.36	.745
5	During residency, I realized that I need to learn continuously to become and stay an expert in my field.	0 (0 %)	0 (0 %)	11 (6.1 %)	59 (32.6 %)	111 (61.3 %)	4.55	.609
Innovative Skills								
6	During residency, I showed that I am willing to keep on learning new aspects related to my discipline.	0 (0 %)	1 (0.6 %)	12 (6.6 %)	84 (46.4 %)	84 (46.4 %)	4.38	.661
7	During residency, I applied my knowledge in new and unfamiliar situations in areas related to my discipline with a degree of success.	0 (0 %)	14 (7.7 %)	67 (37.0 %)	92 (50.8 %)	8 (4.4 %)	3.52	.704
8	During residency, I focused on new challenges.	1 (0.6 %)	6 (3.3 %)	37 (20.4 %)	94 (51.9 %)	43 (23.8 %)	3.95	.791
9	During residency, I approached it like other projects I worked on in the past.	4 (2.2 %)	14 (7.7%)	57 (31.5 %)	82 (45.3 %)	24 (13.3 %)	3.60	.893

10	During residency, I was able to keep on performing at a high level when confronted with unfamiliar situations or tasks.	1 (0.6 %)	14 (7.7 %)	69 (38.1 %)	81 (44.8 %)	16 (8.8 %)	3.54	.785
11	During residency, I was able to apply my knowledge flexible to the different tasks within the project.	1 (0.6 %)	15 (8.3 %)	67 (37.0 %)	75 (41.4 %)	23 (12.7 %)	3.57	.837

Table III: Correlation between total adaptive expertise scores and residency program

			Total AE scores	Year of residency
Spearman's rho	Total	Correlation Coefficient	1.000	.409**
		Sig. (2-tailed)	.	.000
		N	181	181
	Year of residency	Correlation Coefficient	.409**	1.000
		Sig. (2-tailed)	.000	.
		N	181	181

**. Correlation is significant at the 0.01 level (2-tailed).



Graph 1: Comparison between adaptive expertise scores and residents' groups according to the year of residency

DISCUSSION

This study aimed to measure the AE of PGRs and to assess the relationship of AE with years of training. The results obtained established that PGRs acquire adaptive expertise gradually with progression in their residency.

The measurement instrument used in this study consisted of two domains; domain-specific skills and innovative skills with eleven questions. There was no much difference in scores for the knowledge domain among residents of different years. The reason for these results was the concern of residents to keep their knowledge dynamic and up-to-date which exactly denotes the epistemological difference between adaptive and routine experts as frequently discussed in the literature (Bohle Carbonell, Könings, Segers, van Merriënboer, & Psychology, 2016). These findings are also in agreement with perceptions explored by Mylopoulos in her study which stated PGRs are developing awareness about the importance of continuous advancement in knowledge and innovative problem-solving skills to overcome the complex clinical situation in practice (Mylopoulos et al., 2011). Similar results were experienced in a study by Fisher & Peterson on engineers. They found no difference in mean scores in the domain of epistemology between freshmen and engineers (Fisher & Peterson, 2001). The results of study done by Ann F. McKenna showed that there was significant increase in design process knowledge as juniors or freshmen advanced in the design course (McKenna, 2007). Huffman et al., researched on participants including staff physician, residents and medical students to see group variability in time taken and accuracy of solutions of medical cases (Huffman et al., 2018). Results showed significant differences in accuracy in three sets and across three groups. For speed and accuracy among groups; physicians > residents > medical students. Another study done to explore the effect of (EMME) eye movement modelling technique on image diagnostic skills leading to optimal adaptive expertise also reported results similar to our study. Study concluded that use of visual instructional designs can help to nurture adaptive expertise in clinician when confronted with complex or unfamiliar workplace challenges. This effect was more pronounced in experts than medical students (Gegenfurtner, Lehtinen, Jarodzka, Säljö, & Education, 2017). Chen et al., and Hughes et al., also conducted studies to determine the effect of knowledge on AE using simulation exercises. They found domain knowledge and AE were positively correlated with $p < .01$ in both studies (Chen, Thomas, & Wallace, 2005; Hughes et al., 2013).

Regarding innovative skills, most of the residents (46.4%) responded they were willing to learn new aspects related to the field of radiology. This is in line with the qualitative study of Maria Mylopoulos on medical students. She reported concepts of efficiency and innovation should be made clear so that students can inculcate the habits of acquiring problem-solving skills throughout the years of training to be an adaptive future specialist (Mylopoulos & Regehr, 2009). One of four themes drawn in another qualitative study by Mylopoulos was developing a habit of continuous learning throughout clinical practice for being an adaptive expert (Mylopoulos, Lohfeld, Norman, Dhaliwal, & Eva, 2012). Most of the radiology residents nearly 51% also responded that they applied their knowledge in new and unfamiliar situations with a degree of success. As AE is the capability to apply previous conceptual knowledge to a new unfamiliar situation with flexibility and innovation (Ferguson et

al., 2018) so innovative aptitude is the most important facet of AE. Multiple studies have been conducted to teach and develop innovative skills in students. One study by Walker et al., using complex nonfamiliar design scenarios showed senior students exhibited efficiency, confidence, and innovative problem-solving skills persistently before and after the course. However, their junior counterparts developed these competencies with time as they progressed in the course (Walker, Cordray, King, & Brophy, 2006). In response to other survey questions about innovative skills, the majority of residents reacted that during training they focused on new challenges and approached it like other projects they worked on in the past. Similar results have also been reported by Pulakos et al., and Alloworth & Hesketh researched the relationship of past experiences on unpredictable situations and interpersonal dealings. Both studies stated a positive correlation between previous experience gained and unexpected situation(Allworth, Hesketh, & assessment, 1999; Pulakos et al., 2002). Pulakos et al. & Han and Williams also found a strong relationship between previous learning activities or task varieties and adaptive expertise with r = 0.24 and 0.23 respectively (Dawidek, Roach, Ott, & Wilson, 2017; Pulakos et al., 2002).

The results of this study determined PGRs possess AE reflected by their total scores ranged 33-54. Our results further showed a progressive increase in the AE of residents as they advanced in their residency. There was a positive correlation between total AE scores and year of residency with $p < .01$ rejecting the null hypothesis. The results match the conclusions drawn in studies conducted on students of different disciplines and professionals with variable work experience. Walker et al., reported in their study that the senior students exhibited efficiency, confidence, and innovative problem-solving skills persistently before and after the course, however, their junior counterparts also developed these competencies with time as they progressed in the course (Walker et al., 2006). Maria Mylopoulos& Glenn Regehr stated research findings contrary to our results. They explored the perception of medical students about adaptive experts. Their results were not affected by the year of study or the number of clerkships completed. The results showed that students thought they were not accountable to put efforts into being innovative during the learning process rather it was the domain of experts achieved after gaining knowledge and experience (Mylopoulos & Regehr, 2009).

A survey tool only predicts the perception of a person about their belief, as opposed to their actual behavior. Thus, these surveys don't always depict the genuine level of adaptive expertise of an individual. Advance studies with interviews and direct observation of behaviors at the workplace should be planned with a special focus on adaptability, flexibility, and innovation during complex situations. Secondly, AE was only calculated in a single cohort of radiology residents, further studies on postgraduate residents from different disciplines can be conducted to see any difference in adaptability or innovative capabilities (Javed, D. K. 2020). Thirdly, this study only measured AE and established a positive correlation with years of training. Further research should be designed to explore other personal or environmental factors enhancing the adaptability of residents. Moreover, experimental studies can also be planned to explore the innovative axis of adaptive expertise by exposing residents to complex unfamiliar scenarios to assess the sustainability of acquired expertise.

CONCLUSION

This study concludes that radiology residents acquire adaptive expertise perpetually with progression in their training which supports the hypothesis that there is a positive correlation between adaptive expertise and years of training.

Current study advanced previous research data revealing that postgraduate residents have espoused the importance of the dynamicity in knowledge and innovative skills to overcome complex unexperienced clinical situations in practice.

DECLARATION

The author report no declaration of interest.

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2. Usman Mahboob: Critical review and addition of important content.

3. Rabia Ashraf: Data collection and addition of important content.

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