Full Title

Study of Radiologic Technologists' Perceptions of Picture Archiving and Communication System (PACS) Competence and Educational Issues in Western Australia

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Short Title

Study of Radiologic Technologists' PACS Competence

Full Title

Study of Radiologic Technologists' Perceptions of Picture Archiving and Communication System (PACS) Competence and Educational Issues in Western Australia

Abstract

Introduction

Although the implementation of picture archiving and communication system (PACS) could increase productivity of radiology departments, this depends on factors such as the PACS competence of radiologic technologists (RTs). The purpose of this study was to investigate the RTs' perceptions of PACS competence and educational issues in Western Australia (WA).

Materials and Methods

A hardcopy questionnaire was distributed to WA RTs for obtaining their perceptions of PACS competence and educational issues. Descriptive (percentage of frequency, mean and standard deviation) and inferential statistics (t-test and analysis of variance) were used to analyze the responses of the multiple choice and 5 point scale questions from the returned questionnaires.

Results

The questionnaire response rate was 57.7% (173 out of 300). The mean values of all PACS competence questions except questions 2e-g are in the range of 3.9-4.9, i.e. around competent to very competent. Participants indicated they received adequate PACS training (mean: 3.8). Statistically significant variables influencing RTs' perceptions of their PACS competence and educational issues including the age ($p<0.01$), gender ($p<0.05$), years of practice ($p<0.005$-

0.05), primary duty ($p<0.05$), medical imaging qualification ($p<0.001$), general computer skills ($p<0.001$), and type of PACS education received ($p<0.001$-0.05).

Conclusion

The WA RTs indicated they were competent in using the modality workstation, PACS and radiology information system, and received adequate training. However, future PACS education programs should be tailored to different RTs' groups. For example, multiple training modules might be necessary to support the PACS competence development of older RTs and those with lower general computer literacy.

Keywords

PACS competence

PACS education

Radiologic technologist

Introduction

In the last decade, studies confirmed the implementation of picture archiving and communication system (PACS) could increase productivity of radiology departments [1-5]. However, this depends on a number of factors and one of the major factors is the PACS competence of radiologic technologists (RTs) [1,4,6-10]. If the RTs do not have adequate PACS competence, situations such as taking longer to complete radiologic examinations [4, 6], mislabeling of images [9], wasting time to fix the mislabeling [7], and delay in reporting will happen [10]. Recently, the registering bodies such as American Society of Radiologic Technologists (ASRT) and Medical Radiation Practice Board of Australia have suggested that RTs need to have adequate PACS competence for their job and the PACS competence has been considered as one of the key competences of RTs [11,12].

The importance of PACS education has been discussed in the literature [7-13]. There have been a range of PACS education opportunities including trainings provided by academic institutions [14,15], manufacturers [8,14,15], employers [13], professional bodies [14,15], peer-to-peer learning [11,13], and self-directed, independent study [16] available to RTs for some years. It is expected the RTs nowadays should have adequate PACS competence to fulfil their duties because of the increased requirement of registering bodies and availability of learning opportunities. A study of RTs' PACS competence is crucial to confirm this and identify any gaps of current PACS education that might exist. In this way, strategies for minimizing inappropriate use of PACS equipment could be identified leading to enhancement of patient safety and radiologic examination quality [11]. The purpose of this study was to investigate the RTs' perceptions of PACS competence and educational issues in Western Australia (WA).

Materials and Methods

RTs from a total of 42 public and private radiology departments in WA metropolitan and rural areas were asked to take part in this study in June 2013. A hardcopy questionnaire regarding the perceptions of PACS competence and educational issues was distributed to each participant in person or by post depending on the locations of clinical centers and collected through the same channel four weeks later. Their participation was voluntary and they could withdraw at any stage. This study was approved by the institutional ethics committee.

Multiple choice (MC) and 5 point scale questions were developed for the questionnaire to obtain participants' demographic information, and perceptions of PACS competence and educational issues. The contents of the questions were based on literature regarding PACS competence and education [1-11,13-17]. Multiple (and including similar) items were used to measure the constructs of PACS competence and education, and the questionnaire was piloted prior to distribution to ensure reliability and validity [18].

Descriptive and inferential statistics were applied to analyze the questionnaire data. The frequency was obtained for each choice in the MC questions. Means and standard deviations (SDs) were calculated for interval data obtained from the 5 point scale questions. Responses were also divided into cohorts based on the demographic information (e.g. male and female) to calculate the individual means and SDs for each grouping. Mean values between cohorts were compared through either a t-test (for 2 groups) or one way analysis of variance (for 3 cohorts or more). IBM SPSS Statistics Version 22 and Microsoft Excel 2010 were used in

data analysis. A p-value less than 0.05 obtained from inferential statistics was considered statistically significant.

Results

A total of 300 questionnaires were distributed to the identified WA RTs and 173 were returned yielding a response rate of 57.7%. Around half of the participants were between 21 and 30 years old (43.6%) and had 0-9 years of practice (52.0%). Slightly more than two third of the respondents (72.3%) were female. The majority of the RTs had more than 4 years of PACS experience (66.5%), a primary duty in general radiography and fluoroscopy (47.8%), a bachelor degree (62.4%), informal PACS education – learning from peers at work (46.1%), a role in a department as a RT (78.0%), somewhat competent general computer skills (54.9%), and worked in the private sector (66.5%), a hospital (72.3%) and the WA metropolitan area (94.7%). Table 1 summarizes the participants' demographic information.

'Insert Table 1 about here'

Table 2 shows the respondents' perceptions of PACS competence and educational issues. The mean values of all PACS competence questions except questions 2e-g are in the range of 3.9-4.9, i.e. around competent to very competent. Participants indicated they received adequate PACS training for performing their job efficiently (mean: 3.8) and their perceived needs of improvement of PACS knowledge and skills were not too strong (mean: 3.4 and 3.5). No obvious barrier existed for RTs to further their PACS knowledge and skills. The two most effective modes of PACS training and education identified are the instructor led tutorial / workshop (mean: 4.4) and 'informal – learning from peers at work' (mean: 4.2).

‘Insert Table 2 about here’

Tables 3 and 4 demonstrate statistically significant variables that influence RTs’ perceptions of their PACS competence and educational issues including the age, gender, years of practice, primary duty, medical imaging qualification, general computer skills, and type of PACS education received. The following RTs’ groups, younger age (aged 21-40 years) (mean: 4.2-4.4), male (mean: 4.4), fewer years of practice (0-19 years) (mean: 4.2-4.3), with primary duties in computed tomography (CT) (mean: 4.3) and magnetic resonance imaging (MRI) (mean: 4.7), bachelor degree (mean: 4.2-4.4), very competent general computer skills (mean: 4.5), and received PACS education from academic institution (mean: 4.4), manufacturer (mean: 4.4) and more than one channel (mean: 4.3) felt more competent in using the modality workstation, PACS and radiology information system (RIS). The groups with primary duties in CT (mean: 4.6) and MRI (mean: 4.8), very competent general computer skills (mean: 4.7), and received PACS education from more than one channel (mean: 4.6) also had a more positive view on the adequacy of their PACS skills to perform the job. Similarly, the groups with fewer years of practice (0-9 years) (mean: 4.0), primary duty in CT (mean: 4.0), very competent general computer skills (mean: 4.2), and received PACS education from academic institution (mean: 4.1), manufacturer (mean: 4.3), employer (mean: 4.1) and more than one channel (mean: 4.1) were more positive on the issue of adequate PACS training received for performing their job efficiently. However, interestingly, the male cohort (mean: 3.8) and those received PACS education from academic institution (mean: 3.7) expressed stronger needs of improvement of their PACS knowledge and skills than their counterparts.

‘Insert Tables 3 and 4 about here’

Discussion

The participants' demographics presented in Table 1 generally match the demographic pattern of RTs in another state of Australia, Victoria reported in the *Medical Radiation Labour Force* publication by the State Government of Victoria in 2009. For example, around two third of RTs in Victoria were female. The majority of RTs were 25-29 years old. The number of RTs decreased across the 30-45 year age groups and increased again subsequently [19]. Since the participation in this study was voluntary, self-selection bias such as non-participation of RTs with lower computer literacy might exist [20,21]. However, the comparison between participants' demographics and information from the *Medical Radiation Labour Force* report indicates there should be no obvious sampling issue and the findings of this study could be generalized to some extent [19,22].

Question 6 of Table 2 shows the respondents had adequate PACS skills to perform their job (mean: 4.4) and perceived they were competent in using the modality workstation, PACS and RIS (mean: 4.1, question 4). They also felt the competence of RTs in general was comparable to theirs (mean: 3.9, question 5). This suggests the response bias might not be an issue in this study [23]. Their competence ratings in using the modality workstation and RIS for individual tasks seem consistently high (mean: 4.3-4.9, questions 1 and 3). Although similar high mean scores are noted in some of the questions regarding the use of PACS (mean: 3.9-4.5, questions 2a-d), it appears the participants were not competent in using PACS for handling hardcopy film digitalization and archiving, image import from CD-ROM and examination merging (mean: 2.9-3.3, questions 2e-g). Also, except question 2c, the SDs of question 2 were greater than 1 and a noticeable number of respondents selected the choice of

not applicable. These findings are not unexpected because using the modality workstation and RIS for the tasks stated in questions 1 and 3 are the normal duties of every RT and covered in the typical PACS education program [13]. Nonetheless, image import into PACS and examination merging are generally considered as responsibilities of PACS administrators [13,24], and hardcopy film digitalization and archiving seems to be obsolete nowadays due to the widespread PACS implementation in WA for some years [24]. The PACS competence question findings match the participants' responses to the questions of educational issues including feeling of adequate training received, no strong needs of improvement and obvious barrier to further education (questions 7, 10-12). Apparently, no gap exists in the current PACS education model.

A closer look at the findings presented by Table 3 and 4 reveals the above discussion seems to be oversimplified. For the two PACS competence questions in Table 3, the mean values of the 'not competent general computer skills' group are significantly lower than the others. They expressed they did not receive adequate PACS training as well (Table 4). These findings correspond to the idea noted in the ASRT white paper on patient safety and quality in medical imaging examinations published in 2013 that RTs with lower computer literacy tend to have difficulty in using and learning new health information technology [11]. Also, significantly lower PACS competence was perceived by the groups aged over 50 years, with greater than 29 years of practice and medical imaging qualification other than the bachelor, diploma and one obtained overseas (Table 3). Apparently, these three groups would be inter-related. The radiography education is the post-secondary education [25]. Only RTs over 50 years old would have more than 29 years of practice. The certificate in radiography was the previous medical imaging qualification prior to the bachelor and diploma [26]. The other medical imaging qualification could represent the certificate qualification possessed by older

RTs. Although only the ‘greater than 29 years of practice’ group felt significantly less adequate PACS training received (Table 4), the related groups might have this feeling as well but to a lesser extent.

In the online survey study of the relationship between United Kingdom radiographers’ age and confidence in using information management and technology (IM&T) published in 2010 by Rogers et al. [27], their participants were generally confident in using PACS and RIS but the older radiographers reported lower confidence in these aspects because of less exposure to information technology [11,27]. Although similar findings are noted in this study, the effects of gender, primary duty and type of PACS education received on self-perceptions of PACS competence were identified as well (Table 3). The female RTs were significantly less competent than the male counterpart. This finding could be explained by the information processing theory that men and women process information in different ways but computer software is commonly designed based on the male needs causing more disadvantageous for women [28]. The primary duty in CT positively influenced the RTs’ perception of competence and adequacy of training received because CT is one of the early digital modalities and the CT RTs have had more exposure to PACS [1,4]. Also, CT and MRI RTs would be more inclined to learn and manage high-technology equipment [2]. Therefore, significantly higher perceived competence is found in the group with primary duty in MRI. The RTs who received PACS education from the academic institution and manufacturer felt more competent and positive on the adequacy of training received as the module provided by the academic institution appears to be more extensive [29] while the training by the manufacturer would be tailored to the PACS equipment in their workplace [15]. Similarly, the training by the employer would focus on the specific needs of the workplace making their

RTs feel PACS education received adequate and unnecessary to have any further improvement [13].

Although Table 2 shows the 'informal – learning from peers at work' and instructor led tutorial / workshop were perceived as the two effective PACS education channels, Table 3 and 4 reveal only the informal learning would be less adequate. These findings correspond to the suggestion noted in the literature that the instructor led workshop would be more effective than the informal learning approach [13]. Table 3 demonstrates the male RTs and those received PACS education from the academic institution had higher self-perceived PACS competence but they also expressed stronger needs of improvement (Table 4). Apparently, these findings contradict each other. However, this could be explained by the social cognitive theory that individuals would be more eager to learn when they know they could master the subject area [28].

The self-report method (questionnaire survey) was used in this study to investigate the RTs' perceptions of PACS competence and educational issues in WA. The questionnaire survey is commonly used to predict individuals' computer literacy [30-32]. Unlike the study of Rogers et al. focusing on the relationship between age and confidence in PACS [27], this study investigated a number of factors influencing RTs' perceptions of PACS competence and educational issues. Also, the questionnaire used in this study covered a range of PACS and RIS related tasks rather than only general confidence in using PACS and RIS. The use of the hardcopy questionnaire in this study could encourage participation from the group with lower computer literacy. Although the ASRT white paper on patient safety and quality in medical imaging examinations has suggested that there is a close relationship between individuals' computer self-efficacy and their actual competence [11], an observational study on RTs'

performance of handling PACS related tasks would be a better approach to assess their actual competence which could be considered as the direction for further research.

Conclusion

This study investigated the RTs' perceptions of PACS competence and educational issues in WA. The participants indicated they were competent in using the modality workstation, PACS and RIS, and received adequate training for this aspect. However, the age, gender, years of practice, primary duty, medical imaging qualification, general computer skills, and type of PACS education received were identified as the factors influencing their perceptions of PACS competence and adequacy of training. Future PACS education programs should be customized to meet the needs of different RTs' groups. For example, multiple training modules in different formats might be necessary to support the older RTs and those with lower general computer literacy to master this practice area.

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Table 1 Summary of demographic information of radiologic technologists (RTs)

Legends

Note. – PACS=Picture Archiving and Communication System. The number of returned questionnaires was 173 and some questions had missing responses.
[a]Participants could select more than one choice. A=general radiography and fluoroscopy; B=computed tomography; C=magnetic resonance imaging; D=ultrasound; E=mammography; F=angiography; G=other.
[b]A=4-year bachelor degree; B=3-year bachelor degree; C=diploma; D=overseas qualification; E=other.
[c]Participants could select more than one choice. A=training by academic institution; B=training by manufacturer; C=training by employer; D=seminar by professional body; E=informal – learning from peers at work; F=self-directed, independent study.

Table 2 Radiologic technologists' (RTs) perceptions of picture archiving and communication system (PACS) competence and educational issues

Legends

Note. – CD-ROM=compact disc read-only memory, RIS=radiology information system, SD=standard deviation. The number of returned questionnaires was 173 and some questions had missing responses.
[a]Scale of 1 to 5; from not competent to very competent (an additional choice of not applicable also available in questions 2 and 3).
[b]Scale of 1 to 5; from strongly disagree to strongly agree.
[c]Scale of 1 to 5; from not effective to very effective.

Table 3 Comparison of radiologic technologists' (RTs) perceptions of their picture archiving and communication system (PACS) competence

Legends

[a]A=4-year bachelor degree; B=3-year bachelor degree; C=diploma; D=overseas qualification; E=other.
[b]A=only informal - learning from peers at work; B=more than one type.
[c]A=very competent; B=somewhat competent; C=not competent.

Table 4 Comparison of radiologic technologists' (RTs) perceptions of their picture archiving and communication system (PACS) educational issues

Legends

[a]A=very competent; B=somewhat competent; C=not competent.

Table 1 Summary of demographic information of radiologic technologists (RTs)

	Cohort Frequency (%)						
Age (year) (N=172)	21-30 75 (43.6)	31-40 37 (21.5)	41-50 20 (11.6)	>50 40 (23.3)			
Gender (N=173)	Male 48 (27.7)		Female 125 (72.3)				
Years of practice (N=173)	0-9 90 (52.0)	10-19 34 (19.7)	20-29 16 (9.2)	>29 33 (19.1)			
Years of PACS experience (N=173)	<1 9 (5.2)	1-3 49 (28.3)	4-6 59 (34.1)	>6 56 (32.4)			
Nature of workplace (N=164 / 112 / 95)	Public 55 (33.5)		Private 109 (66.5)				
	Hospital 81 (72.3)		Clinic 31 (27.7)				
	Metropolitan 90 (94.7)		Regional 5 (5.3)				
Primary duty (N=314)[a]	A 150 (47.8)	B 84 (26.8)	C 12 (3.8)	D 6 (1.9)	E 36 (11.5)	F 13 (4.1)	G 13 (4.1)
Medical imaging qualification (N=170)[b]	A 57 (33.5)	B 49 (28.8)	C 28 (16.5)	D 29 (17.1)	E 7 (4.1)		
Type of PACS education received (N=330)[c]	A 52 (15.8)	B 26 (7.9)	C 75 (22.7)	D 11 (3.3)	E 152 (46.1)	F 14 (4.2)	
Role in department (N=173)	RT 135 (78.0)	PACS super user 15 (8.7)	PACS administrator 7 (4.0)	Head 16 (9.2)			
General computer skills (N=173)	Very competent 68 (39.3)	Somewhat competent 95 (54.9)	Not competent 10 (5.8)				

Table 2 Radiologic technologists' (RTs) perceptions of picture archiving and communication system (PACS) competence and educational issues

Question	Mean	SD
PACS Competence		
1. My competence in using modality workstation for:[a]		
a. Performing a routine examination (N=173)	4.9	0.4
b. Sending an examination to PACS (N=173)	4.9	0.4
c. Re-sending an examination when any errors happen (N=173)	4.6	0.7
d. Image printing, multi-formatting, and CD-ROM burning (N=172)	4.5	0.9
e. Image manipulation, e.g. adjusting contrast, brightness, annotation, etc. (N=172)	4.7	0.7
f. Manual patient information input when any errors happen (N=173)	4.5	0.9
g. Identification of examinations that are not sent (N=173)	4.6	0.8
2. My competence in using PACS for:[a]		
a. Image printing (N=151)	4.1	1.2
b. Image CD-ROM burning (N=160)	4.3	1.2
c. Past report and image retrieval (N=171)	4.5	0.8
d. Image transfer between two PACS (N=142)	3.9	1.4
e. Hardcopy film digitalization and archiving (N=108)	2.9	1.6
f. Image import from CD-ROM (N=156)	3.3	1.5
g. Examination merging (N=138)	3.0	1.6
3. My competence in using RIS for:[a]		
a. Patient information input or editing (N=172)	4.3	1.0
b. Examination report retrieval (N=171)	4.6	0.7
c. Hardcopy document digitalization and archiving into patient records (N=173)	4.7	0.8
4. My competence in using modality workstation, PACS and RIS (N=173)[a]	4.1	0.8
5. Competence of RTs in using modality workstation, PACS and RIS (N=173)[a]	3.9	0.8
6. Possession of adequate PACS skills to perform my job (N=172)[b]	4.4	0.9
PACS Training and Education		
7. Adequate PACS training received for performing my job efficiently (N=172)[b]	3.8	1.1
8. Feeling of useful functions available in modality workstation, PACS and RIS that I am unware or unable to use (N=172)[b]	3.5	1.1
9. Feeling of better RTs' understanding of PACS contributing to higher department's efficiency (N=173)[b]	3.4	1.1
10. Needs of improvement of my PACS knowledge and skills for more efficient workflow (N=173)[b]	3.4	1.2
11. Needs of improvement of RTs' PACS knowledge and skills (N=170)[b]	3.5	1.1
12. Barriers to further PACS knowledge and skills:[b]		
a. Personally not interested in PACS (N=171)	2.3	1.1
b. RTs generally not interested in PACS (N=170)	2.6	1.1
c. Not enough encouragement from my work environment (N=170)	2.3	1.0
d. Not enough incentive for RTs in general (N=169)	3.3	1.1
e. Not enough opportunity (N=168)	3.1	1.0
f. Unaware of ways of improvement (N=169)	2.8	1.1
13. Effectiveness of different modes of PACS training and education:[c]		

a. Seminar (N=171)	3.0	1.1
b. Instructor led tutorial / workshop (N=171)	4.4	0.7
c. Online tutorial (N=171)	3.1	1.0
d. Informal - learning from peers at work (N=171)	4.2	0.8
e. Formal course provided by academic institution (N=169)	3.1	1.1
f. Self-directed, independent study (N=171)	2.4	1.1

Table 3 Comparison of radiologic technologists' (RTs) perceptions of their picture archiving and communication system (PACS) competence

Question	Cohort (n) Mean±Standard Deviation					P-value / Post-hoc Test
My competence in using modality workstation, PACS and radiology information system	Age					<0.01 / 21-30≠>50; 31-40≠>50
	21-30 (75)	31-40 (37)	41-50 (20)	>50 (40)		
	4.2±0.8	4.4±0.8	4.1±1.0	3.7±0.8		
	Gender					<0.05
	Male (48)		Female (125)			
	4.4±0.8		4.0±0.8			
	Years of practice					<0.005 / 0-9≠>29; 10-19≠>29;
	0-9 (90)	10-19 (34)	20-29 (16)	>29 (33)		
	4.2±0.8	4.3±0.9	4.1±0.8	3.6±0.7		
	Primary duty in computed tomography					<0.05
	Yes (84)		No (89)			
	4.3±0.8		4.0±0.8			
	Primary duty in magnetic resonance imaging					<0.05
	Yes (12)		No (161)			
	4.7±0.5		4.1±0.8			
	Medical imaging qualification[a]					<0.001 / A≠E; B≠C; B≠E
	A (57)	B (49)	C (28)	D (29)	E (7)	
	4.2±0.7	4.4±0.8	3.8±0.7	3.9±0.8	3.1±1.3	
	PACS education received from academic institution					<0.01
	Yes (52)		No (121)			
	4.4±0.8		4.0±0.9			
	PACS education received from manufacturer					<0.05
	Yes (26)		No (147)			
	4.4±0.7		4.1±0.9			
	Type of PACS education received[b]					<0.001
	A (58)		B (95)			
	3.8±0.8		4.3±0.8			
	General computer skills[c]					<0.001 / A≠B; A≠C; B≠C
	A (68)		B (95)		C (10)	
	4.5±0.6		3.9±0.8		3.0±0.5	
Possession of adequate PACS skills to perform my job	Primary duty in computed tomography					<0.05
	Yes (83)		No (89)			
	4.6±0.8		4.2±0.9			
	Primary duty in magnetic resonance imaging					<0.05
	Yes (12)		No (160)			
	4.8±0.5		4.4±0.9			
	Type of PACS education received[b]					<0.01
	A (57)		B (95)			
	4.2±0.8		4.6±0.8			
	General computer skills[c]					<0.001 / A≠B; A≠C; B≠C
	A (68)		B (94)		C (10)	
	4.7±0.5		4.2±0.9		3.6±1.0	

Table 4 Comparison of radiologic technologists' (RTs) perceptions of their picture archiving and communication system (PACS) educational issues

Question	**Cohort (n) Mean±Standard Deviation**				**P-value / Post-hoc Test**
Adequate PACS training received for performing my job efficiently	Years of practice				<0.05 / 0-9≠>29
	0-9 (90)	10-19 (34)	20-29 (15)	>29 (33)	
	4.0±1.0	3.8±1.1	3.8±1.1	3.4±1.2	
	Primary duty in computed tomography				<0.05
	Yes (84)		No (88)		
	4.0±1.1		3.7±1.0		
	PACS education received from academic institution				<0.05
	Yes (51)		No (121)		
	4.1±0.9		3.7±1.1		
	PACS education received from manufacturer				<0.05
	Yes (25)		No (147)		
	4.3±0.7		3.8±1.1		
	PACS education received from employer				<0.005
	Yes (74)		No (98)		
	4.1±1.0		3.6±1.1		
	Type of PACS education received				<0.001
	Only informal - learning from peers at work (58)		More than one type (94)		
	3.4±1.1		4.1±1.0		
	General computer skills[a]				<0.001 / A≠B; A≠C; B≠C
	A (67)	B (95)		C (10)	
	4.2±0.8	3.7±1.1		2.6±1.0	
Needs of improvement of my PACS knowledge and skills for more efficient workflow	Gender				<0.05
	Male (47)		Female (123)		
	3.8±1.0		3.3±1.0		
	PACS education received from academic institution				<0.05
	Yes (51)		No (119)		
	3.7±0.9		3.4±1.1		
	PACS education received from employer				<0.005
	Yes (75)		No (98)		
	3.1±1.2		3.6±1.1		
	Type of PACS education received				<0.05
	Only informal - learning from peers at work (58)		More than one type (95)		
	3.8±1.1		3.3±1.1		