The Dimensionality of the Aarhus University Quality in the PhD Process Survey

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INTRODUCTION AND METHODS

The aim of the following study was to explore possible latent variables underlying individual items as they were used in the Aarhus University *Quality in PhD Process Survey*.

INSTRUMENT

The questionnaire was developed in the spring of 2013. Many of the questionnaire's themes as well as a few individual items originated from prior research on doctoral studies and PhD supervision (Golde & Dore, 2001; Marsh, Rowe & Martin, 2002; Paglis et al., 2006; Trigwell & Dunbar-Goddet, 2005). The rest of the items were developed based on a) a small qualitative pilot-study with eight PhD students and their supervisors, b) theoretical constructs or constructs described in the research literature, and c) the authors' experience as providers of courses on PhD supervision. The questionnaire was presented to deans, vice-deans and leaders of both PhD schools and PhD programmes. The questionnaire was also tested in four focus-group interviews with PhD students from each of the university's four faculties. Based on the feedback, minor revisions were undertaken in the questionnaire.

The questionnaire in full can be found online[b]. *Table 1* shows the means, standard deviations and ranges for the items that were included in the present latent variable analysis. The PhD students were instructed to indicate how much they agreed with the statements on a 5-point Lickert scale ranging from 1 (Disagree) to 5 (Agree). For items 24-28 the scale ranged from 1 (Almost never) to 5 (Almost always). Concerning the questions about research self-efficacy (items 49-56) respondents were asked to indicate to what extent they felt confident managing a number of specified research tasks. The scale ranged from 1 (Not at all confident) to 5 (Very confident). Values 2 through 4 were not labelled for this particular scale.

#	Item	Mean	S.D.	Range
1	Here I meet other PhD students with whom I can exchange ideas	4.25	1.11	1-5
2	If you have any problems related to the PhD programme, you are always welcome to ask one of the other researchers	4.54	0.83	1-5
3	Here I feel respected as a co-researcher	4.30	1.02	1-5
4	There is a sense around here that working together on research is fun	3.98	1.20	1-5
5	The scientific staff members are generally interested in hearing about my project	4.08	1.06	1-5
6	In this research environment, research conducted by PhD students is acknowledged although it may not be groundbreaking	4.16	1.05	1-5
7	Here we present and discuss each other's research on a regular basis	3.86	1.28	1-5

[b] http://www.au.dk/fileadmin/www.au.dk/kvalitetiphd/KIP_Studerende_en_20130916.pdf

#	Item	Mean	S.D.	Range
8	I feel that the researchers here are harsh and negative rather than constructive when giving feedback on each other's work	1.83	1.09	1-5
9	People seem to be very competitive	2.56	1.32	1-5
10	It is possible to talk openly with colleagues about successful as well as unsuccessful experiences	4.09	1.05	1-5
11	I feel like I'm part of the research community here	4.00	1.19	1-5
12	Here both PhD students and professors are welcome to share their opinion	4.39	0.94	1-5
13	I feel that I'm in control of the project	3.91	1.03	1-5
14	I often feel insecure that what I do is good enough	3.45	1.33	1-5
15	Sometimes I wonder if I'm good enough to be a PhD student	3.17	1.53	1-5
16	I feel a sense of ownership of my project	4.33	0.97	1-5
17	It is important to me that I make all the critical choices in my project	3.65	1.07	1-5
18	Sometimes I feel that I'm nothing but an assistant to someone else's project	1.41	0.88	1-5
19	I think that my project is very exciting	4.46	0.82	1-5
20	Overall, I'm satisfied with what I have learned during my PhD process	4.39	0.83	1-5
21	Overall, I'm satisfied with the quality of my research work	4.16	0.93	1-5
22	Overall, I'm satisfied with the quality of my research supervision	4.07	1.13	1-5
23	I can warmly recommend my main supervisor	4.16	1.19	1-5
24	Do you sometimes feel worn out?	3.07	0.94	1-5
25	Do you feel that your work as a PhD student takes up so much time and energy that it affects your private life?	2.90	1.03	1-5
26	Does your work as a PhD student give you severe stress symptoms (e.g. isolation, palpitations, stomach ache, depression, restlessness, memory loss)?	2.23	1.13	1-5
27	Do you feel lonely during your day at your workplace?	2.13	1.14	1-5
28	Do you feel that you act alone in your project and lack the necessary feedback to make progress?	2.31	1.18	1-5
29	My supervisor is friendly and accommodating	4.79	0.61	1-5
30	My supervisor leaves the control of the project to me	4.43	0.85	1-5
31	My supervisor leaves it up to me to take the initiative for supervision	4.21	0.99	1-5
32	My supervisor often seems unprepared for our meetings	2.00	1.22	1-5
33	My supervisor listens to how I want things to be	4.48	0.82	1-5
34	My supervisor encourages me to work independently	4.53	0.80	1-5
35	My supervisor often sets the agenda for the supervision	2.45	1.21	1-5
36	My supervisor makes many important choices in my project	2.76	1.28	1-5
37	My supervisor follows up on whether or not I have time to do the things I need to do	3.20	1.34	1-5
38	My supervisor has clear preferences for the direction my project needs to take	3.31	1.27	1-5
39	My supervisor sets benchmarks and tells me what I need to do	2.60	1.32	1-5

#	Item	Mean	S.D.	Range
40	My supervisor sometimes takes over the writing if I come to a standstill	1.87	1.24	1-5
41	My supervisor has a clear expectation that I will follow the advice I get	3.49	1.16	1-5
42	My supervisor rarely gives specific advice about the best thing to do	2.47	1.23	1-5
43	The relationship between my supervisor and me is characterised by mutual respect	4.61	0.79	1-5
44	My supervisor recognises my work	4.53	0.87	1-5
45	I can openly discuss all problems with my supervisor	4.41	1.00	1-5
46	My supervisor expects me to work so many hours that it's difficult to have a life outside of university	1.79	1.10	1-5
47	Sometimes I have a feeling that my supervisor sees me primarily as a source of labour to advance his/her research	1.50	1.03	1-5
48	My supervisor asks me about my needs and expectations regarding supervision	3.23	1.40	1-5
49	… completing a literature review and summarising the important issues	4.24	0.82	1-5
50	… identifying and posing research questions that are worthy of study	3.96	0.89	1-5
51	… designing well thought out research studies	3.85	0.89	1-5
52	… collecting and analysing empirical data	4.16	0.82	1-5
53	… submitting an abstract to a conference that will be accepted	4.23	0.89	1-5
54	… submit a manuscript to a journal/publisher that will be accepted.	3.68	1.01	1-5
55	… successfully conduct a research project by yourself	3.68	1.00	1-5
56	… be an effective and successful scientist	3.55	1.00	1-5

Introduction to items 49-56: "To what extent do you feel confident managing the following tasks? (Place yourself on a continuum from 1 to 5.)"

SAMPLE

The study was carried out in the autumn of 2013 in all four faculties at Aarhus University, a research intensive Danish university. A total of 2,244 current and former PhD students were invited to complete an online questionnaire. The overall response rate was 79 percent and the response rate varied only slightly between faculties. The descriptive statistics reported in the main report are based on the sample of 1,780 answers. However, on closer inspection, 90 of the 1,780 respondents did provide valid responses to less than 75 percent of the questions. These respondents were omitted from the dataset which is used for the purpose of the present analysis; thus, the statistical analysis presented here is based on a dataset of 1,690 PhD students.

The sample consisted of 47 percent men and 53 percent women aged 23 to 61 with a mean age of 32 (S.D. = 5.95). The PhD students came from the Faculty of Arts (13 percent), the School of Business and Social Sciences (14 percent), the Faculty of Health (32 percent), and the Faculty of Science and Technology (41 percent). Six

percent were former PhD students while 94 were active PhD students in the process of obtaining their PhD degrees.

STATISTICAL ANALYSES

Three separate exploratory factor analyses were conducted in SPSS version 21. The first analysis was conducted on items measuring the PhD students' perception of the interaction with their supervisor. In the questionnaire, respondents were prompted to think of the supervisor with whom the PhD students interacted the most. Thus, the PhD student did not necessarily think of their formal head supervisor. In the second analysis, items describing the PhD students experience with the research and work environment were analysed. This included items about psychological well-being as well as feelings about the research project. In the third analysis, eight items describing the students' research self-efficacy were analysed.

Prior to each analysis, the data was screened for outliers, missing data, and normality. The SPSS Missing Values Analysis module was used to assess missing data, and the Expectation-Maximization (EM) algorithm (Tabachnik & Fidell 2007) was used for imputation of missing values. Principal component analysis (PCA) with subsequent oblique rotation was used as recommended for naturalistic data in which some correlation between component must be expected (Costello & Osborne 2005). Factor solutions that presented the clearest pattern matrix were chosen. Cronbach's alpha was used to assess the scales' internal reliability.

THE RESEARCH AND WORK ENVIRONMENT

The analyses comprised 28 items (items 1-28, see *Table 1*) describing PhD students' perceptions of the research and work environment including items about the PhD students' well-being and feelings about the project.

The initial screening of the data showed that some items were problematic in the light of their distribution; however, since PCA is rather robust to violations to the assumption of normality (Tabachnick & Fidell 2007: 613), all items were retained. Missing values were imputed using the EM algorithm.

In the process of finding an interpretable factor solution, three succinct principal component analyses with oblique rotation (direct oblimin) were run. Two items (items 27 and 20) were omitted one by one because they did not load substantially on any component. The final PCA, thus, was conducted on 26 items. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis (KMO=.914) and Bartlett's test of sphericity $\chi^2(325) = 20973.7$, $p<.001$ indicated that correlations between items were sufficiently large for principal component analysis. Six components had eigenvalues larger than 1 (Kaiser's criterion). The scree plot was slightly ambiguous and showed inflexions that would justify either three or six components.

Table 2. Pattern matrix of the items describing PhD students perception of the research and work environment (N=1,690).

	Collegial research env.	Ownership	Exhaustion	Supervision satisfaction	Harsh tone	Insecurity
	1	2	3	4	5	6
5. The scientific staff members are generally interested in hearing about my project	**0.797**	-0.025	0.016	-0.021	0.03	-0.039
4. There is a sense around here that working together on research is fun	**0.785**	0.016	-0.022	0.065	-0.014	-0.064
11. I feel like I'm part of the research community here	**0.781**	-0.060	0.005	0.040	-0.031	-0.072
6. In this research environment, research conducted by PhD students is acknowledged although it may not be ground-breaking	**0.753**	-0.037	0.007	-0.001	-0.209	-0.024
3. Here I feel respected as a co-researcher	**0.745**	-0.104	-0.046	-0.045	-0.188	-0.077
2. If you have any problems related to the PhD programme, you are always welcome to ask one of the other researchers	**0.745**	0.004	-0.129	-0.016	0.031	0.075
7. Here we present and discuss each other's research on a regular basis	**0.704**	0.097	0.038	0.116	0.210	0.002

	Collegial research env.	Ownership	Exhaustion	Supervision satisfaction	Harsh tone	Insecurity
1. Here I meet other PhD students with whom I can exchange ideas	**0.685**	0.036	-0.098	0.029	0.369	0.066
12. Here both PhD students and professors are welcome to share their opinion	**0.659**	0.010	-0.025	0.053	-0.237	0.051
10. It is possible to talk openly with colleagues about successful as well as unsuccessful experiences	**0.626**	-0.038	0.053	-0.010	-0.336	-0.046
16. I feel a sense of ownership of my project	0.047	**-0.804**	-0.090	-0.043	-0.022	-0.008
17. It is important to me that I make all the critical choices in my project	-0.020	**-0.634**	0.085	-0.077	0.186	-0.056
18. Sometimes I feel that I'm nothing but an assistant to someone else's project	0.058	**0.612**	0.117	-0.087	0.339	-0.113
19. I think that my project is very exciting	0.106	**-0.494**	0.063	0.227	0.167	-0.144
25. Do you feel that your work as a PhD student takes up so much time and energy that it affects your private life?	0.018	0.001	**0.895**	-0.006	0.018	-0.060
24. Do you sometimes feel worn out?	0.022	0.016	**0.836**	-0.015	-0.089	0.090
26. Does your work as a PhD student give you severe stress symptoms?	-0.075	0.032	**0.758**	-0.032	0.029	0.091
23. I can warmly recommend my main supervisor	-0.055	-0.010	-0.027	**0.943**	-0.062	0.124
22. Overall, I'm satisfied with the quality of my research supervision	-0.003	0.001	-0.019	**0.915**	-0.032	-0.018
28. Do you feel that you act alone in your project and lack the necessary feedback to make progress?	-0.149	-0.107	0.149	**-0.576**	-0.051	0.269
9. People seem to be very competitive	-0.103	-0.058	0.089	-0.028	**0.735**	0.100
8. I feel that the researchers here are harsh and negative rather than constructive when giving feedback on each other's work	-0.319	-0.078	0.041	-0.151	**0.595**	0.050
15. Sometimes I wonder if I'm good enough to be a PhD student	0.043	-0.045	0.075	0.111	0.073	**0.873**
14. I often feel insecure that what I do is good enough	0.022	-0.056	0.1	-0.002	0.077	**0.858**
13. I feel that I'm in control of the project	0.072	-0.289	-0.044	0.167	0.088	**-0.515**
21. Overall, I'm satisfied with the quality of my research work	0.110	-0.243	0.105	0.305	0.097	**-0.495**
Eigenvalue	8.330	2.774	1.933	1.358	1.314	1.119
Variance explained	32.0%	10.7%	7.4%	5.2%	5.1%	4.3%
Cronbach's alpha	.914	.593	.814	.839	.670	.777

Note: Principal component analysis with oblique (oblimin) rotation. Loadings >0.4 in bold.

Table 2 shows the factor loadings after rotation. The items clustering on the individual components suggest that component 1 represents a *collegial research environment*, component 2 a sense of *ownership* of the research project, component 3 a feeling of *exhaustion*, component 4 the students' overall satisfaction with PhD supervision, component 5 a *harsh tone* in the research environment, and component 6 a feeling of fundamental *insecurity* about living up to requirements.

PHD SUPERVISION

The analyses comprised 20 items (items 29-48, see *Table 1*) describing PhD students' experience with PhD supervision.

The initial screening of the data showed that some items were problematic in the light of their distribution. Since normality is not a critical assumption as long as it is not used for inference (Tabachnick & Fidell 2007: 613), most of the items were retained. However, item 29 was omitted from the analysis because it was extremely negatively skewed (-3.553). Item 40 was omitted because of 9.6 percent missing values and because, on closer inspection, data was systematically missing. The proportion of missing values was higher in the hard sciences compared with the social sciences and humanities. Missing values for the remaining items were imputed using the EM algorithm.

In the process of finding a satisfactory factor solution, two items were omitted. Item 37 was omitted because it did not load substantially on any component. After rerunning the analysis, item 42 was omitted because it cross-loaded on two components. The final PCA, thus, was conducted on 16 items. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis (KMO=.859) and Bartlett's test of sphericity $\chi^2(120)=9010.2$, $p<.001$ indicated that correlations between items were sufficiently large for principal component analysis. Six components had eigenvalues larger than 1 (Kaiser's criterion). The scree plot showed inflexions that clearly would justify a three-component solution.

Table 3 shows the factor loadings after rotation. We interpreted that items clustering on the same components represent the *interpersonal relationship* between supervisor and PhD student (component 1), *hands-on* supervision (component 2), and *hands-off* supervision (component 3).

An analysis of the components' internal reliabilities showed satisfactory Cronbach's alpha statistics for components one and two. The reliability statistic for component 3 was rather low (α=.594) and the analysis showed that the statistic could be improved (α=.621) if item 34 was deleted. However, since this item was theoretically important and since the validity of a two-item component is questionable, item 34 was retained.

Table 3. Pattern matrix of the items describing PhD students perception of PhD supervision (N=1,690).

	Interpersonal relationship	Hands-on	Hands-off
	1	2	3
43. The relationship between my supervisor and me is characterised by mutual respect	**0.793**	0.039	0.185
44. My supervisor recognises my work	**0.779**	0.082	0.183
45. I can openly discuss all problems with my supervisor	**0.771**	0.088	0.189
47. Sometimes I have a feeling that my supervisor sees me primarily as a source of labour to advance his/her research	**-0.660**	0.274	0.067
48. My supervisor asks me about my needs and expectations regarding supervision	**0.647**	0.122	-0.155
33. My supervisor listens to how I want things to be	**0.640**	-0.029	0.399
32. My supervisor often seems unprepared for our meetings	**-0.586**	-0.08	0.339
46. My supervisor expects me to work so many hours that it's difficult to have a life outside of university	**-0.570**	0.335	0.208
36. My supervisor makes many important choices in my project	0.002	**0.767**	-0.046
38. My supervisor has clear preferences for the direction my project needs to take	0.015	**0.760**	-0.021
41. My supervisor has a clear expectation that I will follow the advice I get	-0.095	**0.688**	0.101
39. My supervisor sets benchmarks and tells me what I need to do	0.245	**0.650**	-0.141
35. My supervisor often sets the agenda for the supervision	-0.045	**0.628**	-0.118
34. My supervisor encourages me to work independently	0.332	0.092	**0.653**
30. My supervisor leaves the control of the project to me	0.097	-0.318	**0.645**
31. My supervisor leaves it up to me to take the initiative for supervision	-0.214	-0.197	**0.644**
Eigenvalue	4.170	3.241	1.345
Variance explained	26.1%	20.3%	8.4%
Cronbach's alpha	0.822	0.774	0.594

Note: Principal component analysis with oblique (oblimin) rotation. Loadings >0.4 in bold.

RESEARCH SELF-EFFICACY

The analyses comprised 8 items (items 49-56, see *Table 1*) describing the PhD students' confidence in their ability to perform a range of research related tasks ranging from conducting a literature review to successfully managing a research project on their own.

The initial screening of the data did not indicate problems with outliers or distributions. Missing values were imputed using the EM algorithm.

In the following PCA, only one component showed an eigenvalue larger than 1 (Kaiser's criterion) and a one-component solution was agreeable with the scree plot. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis (KMO=.870) and Bartlett's test of sphericity χ^2 (28) = 6251.7, p<.001 indicated that correlations between items were sufficiently large for principal component analysis.

Table 4. Structure matrix of the items describing PhD students research self-efficacy (N=1,690).

	Research self-efficacy
	1
55. successfully conduct a research project by yourself	**0.831**
51. designing well thought out research studies	**0.806**
56. be an effective and successful scientist	**0.775**
50. identifying and posing research questions that are worthy of study	**0.769**
54. submit a manuscript to a journal/publisher that will be accepted.	**0.737**
53. submitting an abstract to a conference that will be accepted	**0.668**
52. collecting and analysing empirical data	**0.639**
49. completing a literature review and summarising the important issues	**0.611**
Eigenvalue	4.303
Variance explained	53.8%
Cronbach's alpha	.876

Note: Principal component analysis. Loadings >0.4 in bold.

SCALE PROPERTIES

Ten scales were constructed based on the exploratory factor analyses. Each respondent's score was calculated as the mean response to the items included in the scale. Each scale has a theoretical range from 0 to 10. *Table 5* shows the descriptive properties of each scale.

Table 5. Scale properties.

	Valid N	Min	Max	Mean	S.D.	Skewness	S.E. (skewness)	Items (#) included
1. Collegial research environment	1673	0	10	7.90	2.03	-1.22	0.06	1, 2, 3, 4, 5, 6, 7, 10, 11, 12
2. Ownership	1690	0.63	10	8.14	1.57	-1.06	0.06	16, 17, 18, 19
3. Exhaustion	1688	0	10	4.32	2.22	0.26	0.06	24, 25, 26
4. Supervision satisfaction	1689	0	10	7.44	2.53	-1.09	0.06	22, 23, 28
5. Harsh tone	1647	0	10	3.03	2.67	0.68	0.06	8, 9
6. Insecurity	1690	0	10	4.10	2.39	0.05	0.06	13, 14, 15, 21
7. Interpersonal relation	1690	0	10	8.11	1.75	-1.47	0.06	32, 33, 43, 44, 45, 46, 47, 48
8. Hands-on	1690	0	10	4.79	2.28	0.01	0.06	35, 36, 38, 39, 41
9. Hands-off	1689	0	10	8.48	1.64	-1.51	0.06	30, 31, 34
10. Research self-efficacy	1689	0.71	10	7.29	1.68	-0.40	0.06	49, 50, 51, 52, 53, 54, 55, 56

Table 6 shows the scale intercorrelations.

Table 6. Scale intercorrelations.

	1	2	3	4	5	6	7	8	9
1. Collegial research environment	1								
2. Ownership	.142**	1							
3. Exhaustion	-.337**	-.124**	1						
4. Supervision satisfaction	.493**	.291**	-.374**	1					
5. Harsh tone	-.442**	-0.041	.318**	-.278**	1				
6. Insecurity	-.339**	-.387**	.383**	-.447**	.203**	1			
7. Interpersonal relation	.352**	.372**	-.342**	.661**	-.306**	-.298**	1		
8. Hands-on	.202**	-.237**	-.063**	.246**	0.012	-0.03	-0.007	1	
9. Hands-off	-0.004	.273**	-0.001	-.062*	-0.025	-0.015	.131**	-.382**	1
10. Research self-efficacy	.216**	.427**	-.142**	.293**	-.076**	-.594**	.202**	-.113**	.132**

Person *r* correlations,
*p<.05 (two-tailed), **p<.01 (two-tailed)

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