IOSR Journal of Economics and Finance (IOSR-JEF)
e-ISSN: 2321-5933, p-ISSN: 2321-5925.
PP 62-66
www.iosrjournals.org

Risk Literacy and Numeracy of Students in Business Engineering

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Abstract:*Risk numeracy, how confident people are with probability and graphical displays, is associated with how the deal with risk information. Numerous studies have created indices for measuring numeracy. We tested how good students at our university are in understanding risk information in three different areas: Risk numeracy, graphical literacy and reporting literacy. This is not only important in business for making informed decisions but also in every-day life, e.g. in dealing with health-related risk information. We conducted a survey of all first-year and last-year students with the help of different scales. The results shed some light on the educational attainments of students. It can also help when discussing further designs of the study programme and the discussion of educational techniques such as collaboration or case studies for transferring knowledge into action. It is also useful for companies when assessing capabilities of students.*
Keywords :*graph literacy, risk numeracy, risk reports, statistical numeracy*

I. Introduction

One[2] of the requirements of (future) employers is the ability to correctly deal with different kind of information ('methodological competence') and to be able to apply theoretical concepts in real-world-situations. This is what often is referred to as the 'competence to act' and is one of the major competences Universities officially put at the centre of their educational mission. Such a 'competence to act' builds on several sub-competences and skills of with one basis can be described as statistical numeracy (or risk numeracy if focused on risk information). Statistical numeracy itself "is part of more general concept of quantitative or mathematic literacy" (Galesic and Garcia-Retamero 2013, 16). Questions such as the percentage of 30 cases out of 70, concepts like random tosses of a dice or coin as well as performing calculations with percentages – including conditional probabilities – are part of this numeracy.

To be able to deal with such information is not only crucial in all fields of work but also in other aspects of life like medical information or assessing risks of private investments. This study gives a first insight into the abilities of students to deal with risk information when leaving university compared to when they enter on their first day. It helps in understanding the impact of the curriculum with respect to risk literacy, statistical numeracy and graph literacy.

Several studies already have analysed the level of statistical and risk numeracy for different population samples, mostly highly-educated against non-or "medium" educated samples (e.g. see the works of Cokely et al 2012; Galesic and Garcia-Retamero 2013; Galesic et al 2009).

While such studies have found a link between education, gender and age and the ability to deal with such information (Galesic and Garcia-Retamero 2013), there was still a large variance within such highly-educated samples from different cultures (ebda.). There also seems to be a high correlation of general mathematical abilities with the ability to deal with risk information (Peters and Levin 2008) and the perception of risk (Peters 2008).

These consequences are important in every-day life: people with a higher statistical numeracy seem to be able to make informed decisions based on the information of the cases while people with lower statistical numeracy rely more on emotions and experts' opinion (Peters 2008). Peters et al (2006) could also show that people with lower statistical abilities also tend to choose (objectively) non-dominant options, i.e. make "bad decisions" compared to people with a higher numeracy. But as clear as this tendency may seem, Lipkus, Samsa and Rimer (2001) in their studies found that even those highly-educated people had problems interpreting data in the form of percentages and also had troubles converting proportions into percentages ("1 in 1,000" into %-

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[2] I thank Natalie Benzinger for helping collecting data and entering information.

0.1%). Results were format-depending, i.e. if presented in frequencies ("20 out of 100"), participants were more likely to give correct answers (between 70% and 90% correct answers).

The issue of format-dependency is emerging across all kind of studies. Gigerenzer and Hoffrage (1995) could show that people are able to correctly deal with even conditional probabilities if information is provided in frequencies instead of percentages. Gigerenzer in another study with Zhu could also prove that even young students at the age of 8-10 are able to deal with risk information. If presented in natural frequencies, 40% could answer the questions correctly, when displayed in a graphical way with icons, 60% could answer them (Zhu and Gigerenzer 2006). Garcia-Retamero and Cokely (2013) could also show that the understanding of health risk information could be increased from under 20 to 80% by using certain graphical elements instead of verbal description.

These findings lead to the question of the kind of displaying (or framing) of risk information that would lead to a better understanding of the numbers and would more likely lead to a correct application in every-day life. This was the starting point for our own study: gaining an insight into the understanding of risk-related information displayed in various ways.

II. Study Design

For this study we specifically wanted to gain an insight on the abilities of students in our department when they enter our institution. This is of special importance for us because not the university but our dual partners choose the students as they have a contract with an employer during their study at the DHBW. We also wanted to know if the study of business engineering influences statistical numeracy, i.e. if our programme "makes a difference" compared to when students enter our university.

The study was conducted with the help of a paper-based questionnaire, as this allowed us to collect data simultaneously without running the risk of non-performing IT infrastructure. The negative side is that this meant to enter all information electronically by hand which is time-consuming and a source of errors. All data entries in Excel were therefore checked 100% by another person. Afterwards a third person took a sample of 10% to check again. No errors were found in this last checking sample

We handed out the questionnaire to all first year students on their first day of study during the welcome session in the large lecture hall. Last-year students received the questionnaire six weeks before leaving university in their last semester. This was done to be able to compare the full impact of teaching after completion of study against the incoming batch of students just starting their study and yet not have attended any lectures at the University. This therefore indirectly measures the educational level after leaving school if they directly entered our university.

The questionnaire was divided into four parts as following: the first part measured risk numeracy by making use of a standardised test called the Berlin Numeracy Test (Cokely et al 2012). The second part asked for socio-demographic information like age, gender, grade and the like. Part three consisted of a test of graphical numeracy (graphical representations of information) developed by Garcia-Retamero (see Galesic and García-Retamero 2011 for the test itself) and the last section displayed graphical elements from several 2013 annual reports of German DAX companies (publicly available). These elements were chosen as they aim to inform the public (shareholders specifically) and not only internal addressees. Such a risk reporting is mandatory for German listed companies and regulated by the GAS 20. They are a good way of testing the abilities as the students should be able to interpret such information, at least after completing their study with several lectures on the subject.

For the analysis, we computed a score for each of the three different kinds of numeracy, including a combined score consisting of all three scores. This was done by assigning a score of 1 for correct and 0 for incorrect answers for each index.

III. Results

The following table gives an overview of the main characteristics for the two samples. As the sample consists of students, the groups were very homogenous with respect to age, total grade and the German state of school-leaving certificate. The first test compared the two samples of first-year and last-year students to find out if they differ regarding the four indices.

Table 1: Sample characteristics

	Class of 2012 (n= 108)	**Class of 2014 (n=138)**
Age	21.70 (SD: 1.53)	19.7 (SD: 2.10)
% female	41.30	36.70
% with grammar school-leaving certificate from Baden-Wuerttemberg (“Abitur”)	71.70	74.70
% with 8 year grammar school (“fast track”)	34.00	58.20
Mean grade grammar school (1.0 best)	1.86 (SD: 0.43)	1.92 (SD: 0.52)
Mean grade mathematics (15 highest)	12.36 (SD: 1.55)	11.21 (SD: 3.00)
Mean risk numeracy score (4 highest)	2.06 (SD: 1.00)	1.75 (SD: 1.04)
Mean graphical literacy score (13 highest)	11.12 (SD: 1.48)	11.25 (SD: 1.21)
Mean report numeracy score (18 highest)	13.09 (SD: 2.12)	11.06 (SD: 2.77)
Mean combined score (35 highest)	26.27 (SD: 2.98)	24.06 (SD: 3.44)

As can be taken from the below table, differences between the two samples are significant for the report score and the combined score. The latter is not surprising as the report score forms a large part of the combined score ($r=0.809$, $p<0.01$). The combined score can also be seen as a sufficient proxy for the three different scores computed with Cronbach’s alpha at 0.712 and correlations never under 0.5 for each combination ($p<0.01$).

Table 2: T-Test for both samples

		Levene's Test for Equality of Variances		**t-test for Equality of Means**						
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
									Upper	**Lower**
Numeracy Score	Equal variances assumed	1.042	0.308	2.298	244	0.022	0.302	0.131	0.043	0.561
	Equal variances not assumed			2.307	233.443	0.022	0.302	0.131	0.044	0.560
Graphical Score	Equal variances assumed	1.523	0.218	-0.735	244	0.463	-0.126	0.172	-0.464	0.212
	Equal variances not assumed			-0.717	205.145	0.474	-0.126	0.176	-0.472	0.220
Report Score	Equal variances assumed	6.736	0.010	6.315	244	0.000	2.035	0.322	1.400	2.669
	Equal variances not assumed			6.521	243.882	0.000	2.035	0.312	1.420	2.649
Combined Score	Equal variances assumed	2.017	0.157	5.295	244	0.000	2.211	0.418	1.388	3.033
	Equal variances not assumed			5.387	241.408	0.000	2.211	0.410	1.402	3.019

When we tested for differences between genders, we could find no significant deviation; all scores were very similar, with only risk numeracy as the exception. Only the results for the 2012 batch were different with respect to risk numeracy, but again, not significantly. This is shown in the below Table 3.

Table 3: Gender differences

		Combined sample			2012			2014		
		N	mean	SD	N	mean	SD	N	mean	SD
Risk numeracy score	Male	150	1.97	1.04	62	2.21	.99	88	1.81	1.04
	female	96	1.75	1.02	46	1.85	.99	50	1.66	1.04
Graphical literacy score	Male	150	11.11	1.40	62	11.03	1.62	88	11.17	1.23
	Female	96	11.31	1.22	46	11.24	1.27	50	11.38	1.18
Report literacy score	Male	150	13.08	1.98	62	13.13	1.95	88	10.93	2.94
	female	96	13.06	1.68	46	13.04	2.36	50	11.28	2.48
Combined score	Male	150	24.93	3.67	62	26.37	3.10	88	23.91	3.71
	female	96	25.19	3.02	46	26.13	2.85	50	24.32	2.94

We also tested if grades (mathematics and final school-leaving grades) and test results were significantly different by comparing two-groups according to the median values (median mathematic grade 12; median school-leaving grade 1.9). We found that those with higher mathematic grades had significantly higher scores across all sub-scores ($p<0.05$) as displayed below.

Table 4: Mathematics grades

	Math grade	N	Mean	Std. Deviation
Numeracy Score	>= 12.0	135	2.13	1.03
	< 12.0	72	1.68	.93
Graphical Score	>= 12.0	135	11.25	1.32
	< 12.0	72	10.99	1.46
Report Score	>= 12.0	135	12.43	2.20
	< 12.0	72	11.44	3.37
Combined Score	>= 12.0	135	25.81	3.02
	< 12.0	72	24.11	3.88

The results indicate that we can see mathematical skills (measured as the grade achieved) as a predictor of the understanding of risk information, be they graphically or numerically displayed.

When we compared the two sub-samples according to the total school-leaving grades, we again could find significant differences for all scores ($p<0.05$) with the exception of the graphical scores.

One important factor often cited as a predictor for the success during study is the kind entry qualification. Students normally enter the DHBW with a so called “Abitur”, but other school-leaving certificates are also possible. We therefore tested if these had an influence on the numeracy. The t-test yielded no significant differences across the four indices.

Table 5: School-leaving score

	Total grade	N	Mean	Std. Deviation
Numeracy Score	>= 1.9	108	.77	.99
	< 1.9	108	2.10	1.07
Graphical Score	>= 1.9	108	11.14	1.31
	< 1.9	108	11.25	1.39
Report Score	>= 19	108	11.48	3.06
	< 1.9	108	12.55	2.23
Combined Score	>= 1,9	108	24.39	3.56
	< 1.9	108	25.90	3.10

An additional test looked at if the length of school education (8 years vs. 9 years for the Abitur) has an influence on the results. This is possible as in most states of Germany, students can choose between schools awarding the

"Abitur" after 12 years of total study time and 13 years, which was the norm historically in Germany. Our study found no such significant differences. It also makes no difference if the school-leaving certificate is awarded in Baden-Wuerttemberg or outside, i.e. in other states of Germany as means are not significantly different.

IV. Conclusion

Our study shed some light on the abilities of students to correctly deal with risk information in verbal (risk numeracy scales) and graphical formats. The understanding of statistical and mathematical information and the dealing with it is taught specifically in the first two semesters as part of the two modules mathematics (incl. statistics), while later such aspects are then addressed in numerous modules like engineering mechanics, SPSS, risk management, operations research, technical physics or quality management.

Interestingly, we could find some differences in dealing with risk information provided graphically and numerically. It could be shown that students when leaving our institution have a better understanding of risk information provided graphically in the form of risk reports ($p<0.01$). Risk numeracy is also significantly higher after six semesters of study. If this goes back to the educational attainments achieved during study or just because the two samples had different characteristics when entering university, is not yet clear as the mathematical grades are significantly different between the two groups, but not total grades. At least to seems to make a difference to study six semesters of business engineering with respect to the understanding of risk information.

A critical point concerning the validity of the study could be the only medium effect size of around 0.69 (as computed by G-Power with α error prob. = 5%, post hoc) for the combined score, despite the fact that power is at 0.99. This means that the differences of the two groups are there and not negligible, but itself are not very strong. In the case of report scores, the effect size is up to 0.82, which is large enough for such a study. This is explainable by the fact that such reports are normally not discussed in school, but during study of business engineering in several modules like Controlling, Finance or Risk Management. This means that for this sample we could demonstrate that attending courses increases the understanding of risk information as capture by the combined index.

More research is needed to understand the process of information gathering itself, i.e. how students or the general population come up with the answers. In addition, the study could be conducted at other universities and in other study subjects like business administration or law to work out differences or commonalities. For our department, it provides valuable insights on the performance of students in real-world examples and helps us in revising the curriculum for the next accreditation.

References

[1]. M. Galesic and R. Garcia-Retamero, Statistical numeracy for health, in M. Galesic, R. Garcia-Retamero (Ed.). *Transparent communication of health risks* (New York et al: Springer 2013) 15-28.
[2]. E. T. Cokely, M. Galesic, E. Schulz, S. Ghazal and R.Garcia-Retamero, Measuring risk literacy: The Berlin Numeracy Test, *Judgment and Decision Making, 7(1),* 2012, 25-47.
[3]. M. Galesic, G. Gigerenzer and S. Straubinger, Natural frequencies help older adults and people with low numeracy to evaluate medical screening tests. *Medical Decision Making, 29(5),* 2009, 368-371.
[4]. E. Peters and I. Levin, Dissecting the risky-choice framing effect: Numeracy as an individual-difference factor in weighting risky and riskless options. *Judgment and Decision Making, 3(6*), 2008, 435–448.
[5]. E. Peters, Numeracy and the Perception and Communication of Risks. *Annals of the New York Academy of Science, 11,* 2008, 281-7.
[6]. E. Peters, D. Västfjäll, P. Slovic, C. K. Mertz, K. Mazzocco and S. Dickert, Numeracy and decision making. *Psychological Science, 1785),* 2006, 407–413.
[7]. I.M. Lipkus, G. Samsa and B.K. Rimer, General performance on a numeracy scale among highly educated samples. *Medical Decision Making, 21(1)*, 2001, 37-44.
[8]. L. Zhu and G. Gigerenzer, Children can solve Baynesian problems: the role of representation in mental computation, *Cognition, 98(3),* 2006, 287-308.
[9]. R. Garcia-Retamero and E. T. Cokely, Communicating health risks with visual aids. *Current Directions in Psychological Science, 22(5),* 2013, 392-399. DOI: 10.1177/0963721413491570
[10]. M. Galesic and R. García-Retamero, Graph literacy: A cross-cultural comparison. *Medical Decision Making, 31(3),* 2011, 444-457.
[11]. G. Gigerenzer and U. Hoffrage, How to improve Bayesian reasoning without instruction: Frequency formats. *Psychological Review, 102(4),* 1995, 684-704.