MOTIVATION AND SELF-EFFICACY RELATED TO PROBABILITY AND STATISTICS: TASK-SPECIFIC MOTIVATION AND PROFICIENCY

Martin Gundlach, Sebastian Kuntze, Joachim Engel and Laura Martignon
Ludwigsburg University of Education, Germany
gundlachmarti@ph-ludwigsburg.de

Motivational characteristics of learners have shown to be more predictive for proficiency when they are measured for a specific content domain. For proficiency in the area of probability and statistics, there is still a need for research on the role of motivational variables. In particular, task-specific motivation and interest might contribute to our understanding of the impact of motivational dispositions on the use of learning opportunities. Accordingly, this paper presents empirical results in this area, which are part of the research project RIKO-STAT. We concentrate on the data of 350 prospective teachers, who were asked about content domain-specific and task-specific motivation and self-efficacy and about solutions to given tasks which were parallelised with the motivation questionnaire. The results suggest interdependencies between task-specific motivation and the proficiency of solving the tasks.

THEORETICAL BACKGROUND

Dispositions of learners in the area of motivation are considered as meaningful influencing variables that have an impact on learning outcomes and hence on proficiency (Helmke & Weinert, 1997; Deci & Ryan, 1993). Among the variety of variables in this area, the two constructs of interest and self efficacy (Heckhausen, 2006; Krapp, 1992; Bandura, 1977) have been extensively investigated and widely accepted in empirical research. One of the main claims has been that the more content-specific these variables are measured, the more predictive they are for proficiency and future learning outcomes, e.g. in mathematics. As there is still a need for corresponding research for the content area of statistics and probability, we focus on this content area in order to examine whether this claim also holds for specific content areas. In this study, we integrate and compare mathematics-related, statistics-specific, and even task-specific interest and self efficacy variables. Moreover, proficiency data was gathered for the same tasks the task-related variables had been referring to.

Our approach to statistics and probability is in line with the theoretical background of the project RIKO-STAT presented in Kuntze, Engel, Martignon and Gundlach (submitted) and Kuntze, Lindmeier & Reiss (2008). According to this approach, motivational variables as the ones considered here are being looked at as influencing variables on competency development in the broader domain of statistical literacy (cf. Kuntze et al., submitted; Watson & Callingham, 2003). In a deepening approach for the case of proficiency in statistics and probability, this study focuses on expected interdependencies between motivational variables situated on the different levels of content-specificity introduced above and shown in Figure 1.

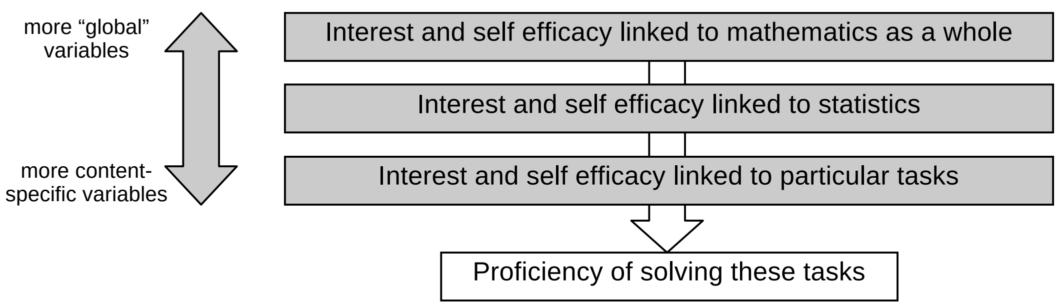

Figure 1. Levels of content-specificity of motivational variables considered in this study

RESEARCH QUESTIONS

Corresponding to the model introduced above, the following research questions address potential interdependencies expected according to the overview in Figure 1:

In C. Reading (Ed.), *Data and context in statistics education: Towards an evidence-based society. Proceedings of the Eighth International Conference on Teaching Statistics (ICOTS8, July, 2010), Ljubljana, Slovenia*. Voorburg, The Netherlands: International Statistical Institute. www.stat.auckland.ac.nz/~iase/publications.php

- What interest and self-efficacy dispositions do learners have related to the areas of mathematics (general), statistics, and when being confronted with particular tasks?
- What interdependencies among these variables and with the proficiency of solving tasks can be observed?

DESIGN AND SAMPLE

The sample of this study consisted of 360 university students (56 male, 303 female, one without data, age M=22.73, SD=3.65), who were asked to complete a multiple-choice questionnaire on their motivation in mathematics and statistics (five-point Likert scale). A sub-sample of 167 students (randomised assignment) was given an additional questionnaire about their task-specific interest and self-efficacy (five tasks). At a later stage of completing the questionnaire, the students were asked to solve the tasks they had evaluated from a motivational point of view before. All of these questionnaire units were part of a larger questionnaire and test instrument (Kuntze et al., submitted). As the questionnaire and test was administered to the students before the start of their academic courses at the beginning of the teaching term, a potential influence of these courses was minimised. Moreover, the aims of the project RIKO-STAT were not made explicit to the students before answering the questionnaire, in order to avoid biased answers.

RESULTS

As the non-mathematics-related parts of the questionnaire instrument were new developments, we will first report results about the properties of the questionnaire instrument. In Tables 1 and 2, sample items for the questionnaire scales can be found together with the corresponding reliability values. The reliability values are good.

Table 1. Motivational variables related to mathematics and statistics: Scales and reliability values

Scale	**Sample item**	**Number of items**	**Alpha (Cronbach)**
Self-efficacy (mathematics)	I can solve maths tasks well.	6	.95
Interest (mathematics)	I am interested in mathematics.	6	.91
Self-efficacy (statistics)	I can solve statistics tasks well.	8	.93
Interest (statistics)	I am interested in statistics.	3	.80

Table 2. Task-specific motivational variables: Scales and reliability values

Scale	**Sample item**	**Number of items**	**Alpha (Cronbach)**
Task-specific self-efficacy	I am certain that I can solve this problem correctly.	5	.86
Task-specific interest	I am sure working on this problem would be fun for me.	10	.96

Furthermore, the parallelised scales for the content domains of mathematics and statistics reflected empirically different constructs, as corresponding factor analyses show (see Tables 3 and 4). The items of the scales can be found on two separate factors, respectively. The factor analyses presented in Tables 3 and 4 explain 72.3 % resp. 71.0 % of the variance.

Corresponding to the first research question, Figure 2 displays the means for self-efficacy and interest, both related to mathematics as well as statistics, respectively, and for the task-specific motivational variables. The means for self-efficacy and interest in mathematics and statistics appear to differ little from each other. The self-efficacy is close to the centre of the scale, while interest variables deviate somewhat downwards from the centre of the scale. With respect to task-specific motivation, the students saw their capacities to solve the problems correctly in a more positive way than they evaluated their self-efficacy. For task-specific interest, there is a similar observation of more positive ratings.

Table 3. Factor analysis for self-efficacy scales (statistics vs. mathematics)

Item	**Factor 1**	**Factor 2**
Stat_SE1	.748	
Stat_SE2	.816	
Stat_SE3	.850	
Stat_SE4	.865	
Stat_SE5	.841	
Stat_SE6	.783	
Stat_SE7	.727	
Stat_SE8	.641	
Math_SE1		.883
Math_SE2		.859
Math_SE3		.882
Math_SE4		.839
Math_SE5		.879
Math_SE6		.844

(Factor loads below 0.4 not displayed)

Table 4. Factor analysis for interest scales (statistics vs. mathematics)

Item	**Factor 1**	**Factor 2**
Stat_I1	.862	
Stat_I2	.866	
Stat_I3	.757	
Math_I1		.883
Math_I2		.703
Math_I3		.900
Math_I4		.778
Math_I5		.848
Math_I6		.782

(Factor loads below 0.4 not displayed)

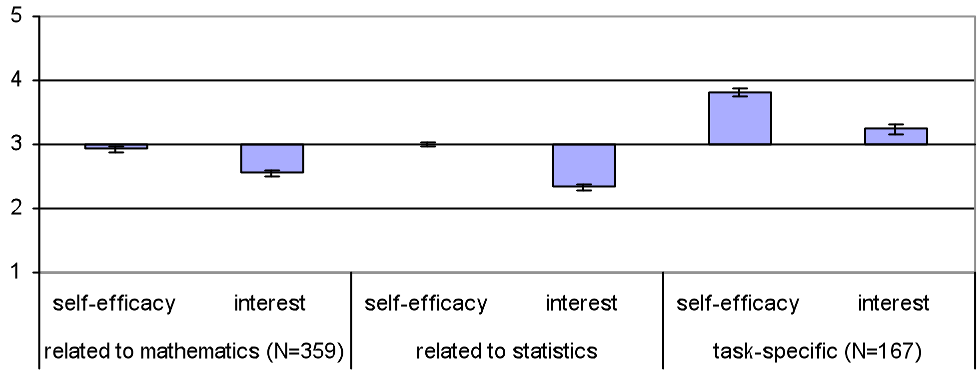

Figure 2. Mean values and standard errors for motivational variables

Table 5. Correlations of self-efficacy, interest and task-specific motivation variables

Correlations (Pearson)	Interest (mathematics)	Self-efficacy (statistics)	Interest (statistics)	Task-specific interest	Task-specific self-efficacy
Self efficacy (mathematics)	.76**	.53**	.32**	.34**	.37**
Interest (mathematics)		.42**	.40**	.51**	.31**
Self efficacy (statistics)			.60**	.30**	.48**
Interest (statistics)				.39**	.36**
Task-specific interest					.43**

**: correlation significant with p<0,01. Cases with complete data considered, N=164.

Table 6. Linear Regression for task-specific motivational variables

Regression coefficients for	Self efficacy (mathematics)	Interest (mathematics)	Self-efficacy (statistics)	Interest (statistics)	R-Square
Task-specific interest	-.18; [-.42; .06]	**.55*****; [.33; .78]	.07; [-.17; .30]	**.26***; [.05; .47]	.31
Task specific self efficacy	.12; [-.08; .32]	.03; [-.16; .23]	**.33****; [.12; .53]	.11; [-.07; .28]	.24

Regression coefficients and [95%-confidence interval]; *: p < .05; **: p < .01; ***: p < .001

Referring to the second research question about interdependencies between the variables considered in this study, Table 5 shows the correlations among self-efficacy and interest variables (mathematics and statistics) and task-specific motivation. All variables appear to be interrelated. Focusing on task-specific variables, a linear regression (Table 6) shows that task-related interest is above all interrelated with mathematics-specific interest, whereas task-related self-efficacy interdepends above all with its statistics-specific counterpart.

Finally, we analysed interdependencies between task-specific motivation variables and task-specific proficiency. When looking at the total score of the five tasks, there is a relatively low correlation of r=0.28 (significant with p<0.01) between the score and the task-specific self-efficacy. For the task-specific interest scale, there is no significant correlation with the proficiency score. However, in more detailed analyses focusing on the evaluations of each of the tasks and their rates of solutions, respectively, the evidence suggests more visible interdependencies.

DISCUSSION AND CONCLUSIONS

The results suggest that mathematics and statistics-specific self-efficacy and interest are interdependent with each other and with task-related motivation. However, the correlation values suggest that these motivational constructs do not coincide. For example, the correlations within the content areas of mathematics and statistics tend to be higher than the correlations across content areas. The task-specific interest interdepends more with interest for mathematics, whereas the task-specific self-efficacy correlates, as expected, with the more specific statistics-related self efficacy.

The correlation data involving the aggregated proficiency score seems not to support the claim that context-specific motivational measures are more predictive for proficiency, as the corresponding correlations are rather low. However, the aggregated level of analysis may not reflect the task-specific evaluations of the students in the best way, as inter-task variation may not be considered sufficiently. Hence, deepened analyses in this area could add to a supplementary understanding of task-related motivation in the content area of statistics and probability.

Furthermore, the data in Figure 2 highlights that motivational variables on the task-specific and on the more general content domain-specific level can be remarkably different. This suggests that the tasks referred to might play a crucial role. Further research questions derived from this observation concern interdependencies of characteristics of the tasks on the one hand and task-related motivational variables on the other. Further evidence in this area can contribute to an evidence-based design of motivating learning environments in the area of statistics and probability.

Last but not least, the empirically successful development of a questionnaire instrument which includes statistics-specific scales will enable us to use this instrument in evaluation studies which focus on developments of domain-specific motivation. Such studies can be helpful for the every-day design of learning opportunities in the classroom.

ACKNOWLEDGEMENT

This research is supported by research grants of Ludwigsburg University of Education.

REFERENCES

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioural change. *Psychological Review*, *84*, 191-215.

Deci, F., & Ryan, R. (1993). Die Selbstbestimmungstheorie der Motivation und ihre Bedeutung für die Pädagogik. *Zeitschrift für Pädagogik*, *39*, 223-238.

Heckhausen, J., & Heckhausen, H. (2006). Motivation und Handeln. (3. Auflage). Berlin: Springer.

Helmke, A., & Weinert, F. (1997). Bedingungsfaktoren schulischer Leistungen. In: F. Weinert (Hrsg.), Enz. d. Psych. Bd. 3: Psych. d. Unt. u. d. Schule (pp. 71–176). Göttingen: Hogrefe.

Krapp, A. (1992). Das Interessenskonstrukt. In A. Krapp & M. Prenzel (Hrsg.), Interesse, Lernen, Leistung. Neuere Ansätze der pädagogisch-psychologischen Interessensforschung (pp. 197-329). Münster: Aschendorff.

Kuntze, S., Engel, J., Martignon, L., & Gundlach, M. (submitted). Aspects of statistical literacy between competency measures and indicators for conceptual knowledge–empirical research in the project “RIKO-STAT”. ICOTS 2010.

Kuntze, S., Lindmeier, A., & Reiss, K. (2008). “Using models and representations in statistical contexts” as a sub-competency of statistical literacy–Results from three empirical studies. *11th Int. Congr. on Math. Education (ICME 11)*. Online: http://tsg.icme11.org/document/get/474.

Watson, J., & Callingham, R. (2003). Statistical literacy: A complex hierarchical construct. *Statistics Education Research Journal*, *2*(2), 3-46.