ARE VALUES RELATED TO STUDENTS' PERFORMANCE?

Stanislaw Schukajlow

University of Münster, Germany

Values are believed to be important for students' affect and achievements. In the present study, I administered task-unspecific and task-specific questionnaires to investigate a connection between students' values and performance in solving problems with and without a connection to the real world. 192 ninth graders were randomly assigned to group 1 or group 2. In group 1, students reported their values after task processing; and in group 2, they reported their values before task processing. The main result was in line with expectations: Students who achieved higher scores on the performance test reported higher values, and students who valued mathematics and problem solving activities performed better on the tests.

INTRODUCTION

Values are an important part of affect. However, they are the least studied of the affective measures in mathematics education (Zan, Brown, Evans, & Hannula, 2006). Prior research on values has focused mostly on values in mathematics teaching, which are reflected, for example, in school text books (Bishop, Seah, & Chin, 2003) or on case studies that have demonstrated the importance of values for changes in students' affect (Hannula, 2002). In education, a number of studies have been conducted to investigate the relation between values and students' achievement. However, only some of them have focused on mathematics, and in doing so, they have often included course choices or grades but not students' performance as indicators of achievement. In the present study, I examined whether students' performance on problems with and without a connection to the real world would be found to be related to students' task-unspecific and task-specific values, measured before and after task processing.

THEORETICAL BACKGROUND

Values and their relation to performance

Values have been investigated in cultural, social, and psychological contexts (Bishop et al., 2003) and refer to the subjective importance of objects (e.g., mathematics), actions (e.g., problem solving), or outcomes (e.g., grade in mathematics) for human beings. Values are believed to be valuable appraisals of motivation and emotions. Research on values has often been embedded into motivational and emotional theories such as the control-value theory of achievement emotions. For example, students' values were hypothesized to trigger their enjoyment, and positive changes in students' values were found to be related to positive changes in their enjoyment (Buff, 2014).

2017. In Kaur, B., Ho, W.K., Toh, T.L., & Choy, B.H. (Eds.). *Proceedings of the 41st Conference of the International Group for the Psychology of Mathematics Education*, Vol. 4, pp. 161-168. Singapore: PME.

Values can be traditionally categorized as intrinsic or extrinsic (or utility) values (Pekrun, 2006). Whereas persons with high intrinsic values ascribe high valence to mathematical activities per se, persons with high utility values do it because of the usefulness of these activities for their career, grades, or other indicators of success.

Students' high values are believed to influence their career-related choices, efforts in learning, persistence in achievement-related activities, and thus also to predict their learning outcomes such as performance (Guo, Marsh, Parker, Morin, & Yeung, 2015). In turn, the feedback students receive from their learning outcomes influences their responses to affective variables. Thus, higher performance in mathematics can trigger higher values with respect to mathematical activities (Simpkins, Davis-Kean, & Eccles, 2006). The hypothesized positive relation between students' values and their achievements in mathematics has partly been confirmed in empirical studies. High values in mathematics were found to be related to higher mathematics grades in the 10^{th} grade but not to higher mathematics grades in the 5^{th} grade (Simpkins et al., 2006). Intrinsic and extrinsic values were found to be positively connected to mathematical performance in Grade 8 (Guo et al., 2015).

Characteristics of measures of values

Solving mathematical problems is a complex process that is accompanied by different affective phenomena. Efklides (2006) distinguished between prospective, current, and retrospective affect measured before, during, and after problem solving activities, respectively. Students' prospective values indicate the importance they ascribe to problem solving before they start the solution process. Students' retrospective values indicate the importance they ascribe to task processing after it is completed. Both the prospective and retrospective valuing of problem solving activities are important for students' performance and achievements (Schukajlow & Krug, 2014).

Several calls in mathematics education have demanded that a variety of instruments be used to assess affect and to take into account the domain-specificity of affect (Zan et al., 2006). One way to heed these calls is to complement the well-known task-unspecific affective scales with a novel task-specific approach (Schukajlow et al., 2012). The application of two different measures of affect further allow researchers to examine the stability of the correlations between performance and affective measures. A main difference between the task-unspecific and task-specific approaches is the level of object specificity (Schukajlow, 2015). Whereas task-unspecific measures describe the object more generally, in task-specific questionnaires, the object of interest is specified in more detail. For values, task-unspecific questionnaires typically refer to the value of learning mathematics, whereas task-specific questionnaires refer to the value of solving a sample problem such as $2x + 4 = 9$. In the present study, I expected that the relation between students' values and performance would be similar for task-specific and task-unspecific measures because the two types of questionnaires assess the same constructs.

Problems with and without a connection to reality

Mathematical problems can be divided into two types of problems: problems with a connection to reality and problems without a connection to reality (or intra-mathematical problems) (Rellensmann & Schukajlow, in press). Problems with a connection to reality include modelling and "dressed up" word problems (Blum, Galbraith, Henn, & Niss, 2007). To solve modelling problems, students need to construct a situation model, which they then simplify and idealize before constructing a mathematical model. Further, students need to interpret and validate their results at the end of the solution process. "Dressed up" word problems present a simplified situational model, and thus, students can proceed with the mathematizing process directly after the task comprehension process. Moreover, they do not need to perform sophisticated interpretation and validation activities after calculating the mathematical results. Both types of real-world problems are important for learning mathematics (Schukajlow et al., 2012).

As problems with and without a connection to reality are essential parts of the curriculum in different countries, we chose these problem types to investigate the connection between values and performance. In a previous study, we found that students valued very similar problems with and without a connection to reality (Schukajlow et al., 2012). However, to the best of my knowledge, no studies have previously compared the relation between values and performance for these two types of problems. As both types of problems are mathematical problems, I did not expect that there would be a significant difference in the correlation between performance and values when comparing problems with and without a connection to reality.

PRESENT STUDY: RESEARCH QUESTIONS AND EXPECTATIONS

The present study was embedded in a research project aimed at investigating task-specific affect and its relation to performance (Rellensmann & Schukajlow, in press; Schukajlow, 2015). In the present paper, I addressed the following questions:

1) Is students' performance in mathematics positively connected to their task-unspecific and task-specific values measured *after* problem solving? Are students' task-unspecific and task-specific values measured *before* problem solving positively connected to their performance in mathematics?

2) Is students' performance connected more strongly to their *task-specific* than to their *task-unspecific* values measured after problem solving? Are students' *task-specific* values measured before problem solving connected more strongly to their performance than their *task-unspecific* values are?

3) Are correlations between performance and values measured after problem solving different for problems *with and without a connection to reality*? Are correlations between students' values measured before problem solving and performance different for problems *with and without a connection to reality*?

On the basis of theoretical considerations, a positive relation between performance and values was expected; students' performance was expected to be similarly related to task-specific and task-unspecific values; correlations between performance and values were expected to be comparable for problems with and without a connection to reality.

METHOD

One hundred ninety-two ninth and tenth graders from German middle track and grammar school classes (53.6% female; mean age=16.1 years) were randomly assigned to group 1 or 2. In group 1, students solved the problems first and afterwards filled out task-specific and task-unspecific questionnaires that assessed their values. In group 2, students first filled out both types of questionnaires and then solved the problems (Fig. 1).

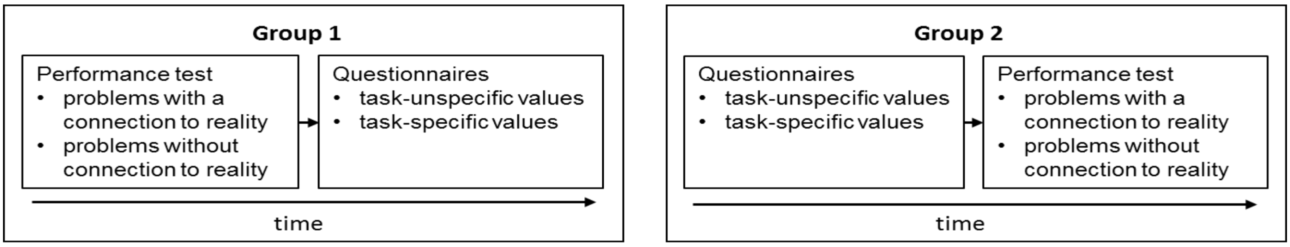

Fig.1: An overview of the study

Example of problems with and without a connection to reality

Sixteen problems with a connection to reality and seven problems without a connection to reality that could be solved by applying Pythagoras' theorem and linear functions were selected for this study. These problems were used to assess students' performance and their task-specific values. Sample tasks on the topic of Pythagoras' Theorem are presented below (for more sample tasks, see Rellensmann & Schukajlow, in press; Schukajlow et al., 2012).

Maypole

Every year on Mayday in Bad Dinkelsdorf, there is a traditional dance around the maypole (a tree trunk approx. 8 m high). During the dance, the participants hold ribbons in their hands, and each ribbon is fixed to the top of the maypole. The participants dance around the maypole with these 15-m-long ribbons, and as the dance progresses, the ribbons produce a beautiful pattern on the stem (such a pattern can already be seen at the top of the maypole stem in the picture).

At what distance from the maypole do the dancers stand at the beginning of the dance (the ribbons are tightly stretched)?

Fig. 2: Problem with a connection to reality "Maypole"

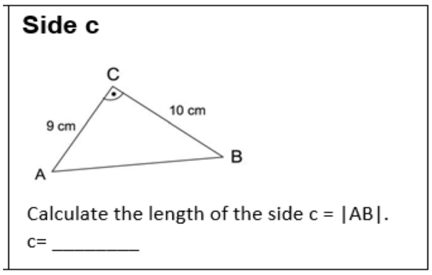

Fig. 3: Problem without a connection to reality "Side c"

Performance

Students' performance in solving problems with and without a connection to reality was measured with 16 and 7 problems, respectively. Cronbach's alpha as a measure of reliability for the test of the ability to solve problems with a connection to reality was satisfactory (.77). The reliability for the test of performance on problems without a connection to reality was low (.52) but acceptable for the small number of items and the diversity of mathematical procedures needed to solve the problems.

Task-unspecific and task-specific values

Task-unspecific values were assessed via the intrinsic component with scales that were taken from other studies and consisted of 5 statements that were answered on 5-point Likert scales ranging from (1=strongly disagree) to (5=strongly agree). A sample item is "Mathematics is my favorite subject." Cronbach's alpha was .85. To assess task-specific values, each of the 23 problems was followed by a statement about the extent to which the students valued the processing of the task. The instructions were: "Read each problem carefully and then answer some questions. **You do not have to solve the problems!**" After task processing, the students in group 1 were presented the problems again and were asked to rate the extent to which they agreed or disagreed with the statement "I think it is important to be able to solve this problem." Students in group 2 were asked before task processing to rate the same statement. A 5-point Likert scale was used to record their answers (1=not at all true, 5=completely true). One scale measured task-specific values for problems with a connection to reality and was formed across 16 problems (Cronbach's alpha=.96). Another scale measured task-specific values for problems without a connection to reality and was formed across 7 problems (Cronbach's alpha=.91).

An implementation check indicated that students in group 1 solved the problems significantly more often than students in group 2 *before* they reported their values (Schukajlow & Krug, 2014).

RESULTS

The analysis of the relation between students' performance and values assessed after task processing confirmed my expectations. Students who achieved higher scores on the tests valued mathematics and solving mathematical problems higher than students who achieved lower scores (see Table 1).

		task-specific values		task-unspecific values
		problems with a connection to reality	problems without a connection to reality	
performance	problems with a connection to reality	.386**		.500**
	problems without a connection to reality		.240**	.233*

Note: ***p*<.01; **p*<.05; one-tailed; sample size N=100.

Table 1: Pearson correlations between performance and task-specific and task-unspecific values after task processing (group 1).

Similar correlations were found for the relation of values measured before task processing and performance (Table 2), indicating that students with higher values with respect to mathematics and problem solving activities before task processing achieved higher scores on the performance test. However, three of four correlations just missed the significance level of .05, and thus the results should be interpreted cautiously.

		task-specific values		task-unspecific values
		problems with a connection to reality	problems without a connection to reality	
performance	problems with a connection to reality	.157[a]		.332**
	problems without a connection to reality		.149[a]	.145[a]

Note: ***p*<.01; **p*<.05; [a]*p*<.10; one-tailed; sample size N=92.

Table 2: Pearson correlations between performance and task-specific and task-unspecific values before task processing (group 2).

To answer the second and third research questions, I compared the correlations with Fisher's *Z*-scores and two-tailed significance tests (Steiger, 1980). In group 1, the correlations between performance and task-unspecific values did not differ from the correlations between performance and task-specific values. For example, the *Z*-score for the comparison between the correlations of .386 and .500 in Table 1 was 1.147 and was not significant (*p*=0.252). Similar results were found for the comparison of correlations in group 2 for problems without a connection to reality (.145 and .149) and for problems with a connection to reality (.157 and .332). The latter difference in correlations was found to be marginally significant (*Z*=1.726, *p*=.084) and indicated that students' task-unspecific values tended to be more closely related to performance than students' task-specific values for problems with a connection to reality.

In investigating the third research question, I was interested in differences in correlations between two types of problems: problems with and without a connection to reality. As expected, correlations between performance and task-specific values measured after task processing (.386 and .240) did not differ significantly between the two types of problems (*Z*=1.507, *p*=.132). However, the correlation between performance and values for problems with a connection to reality (.500) was higher than the same correlation for problems without a connection to reality (.233, *Z*=2.969, *p*=.003). Similar results were found for the relation of values measured before task processing and students' performance. There was no significant difference between the two problem types in the task-specific correlations (.157 and .149), but there was a difference for the task-unspecific ones (.332 and .145, *Z*=2.057, *p*=.040).

SUMMARY AND DISCUSSION

The aim of the study was to investigate the relation between performance and values. To achieve this aim, students' values were assessed before and after task processing, using task-specific and task-unspecific questionnaires and using problems with and without a connection to reality. As predicted by motivational theories (Guo et al., 2015), performance and values were found to be related to each other. This result indicates that students' performance might be important for the development of values and vice versa. The reciprocal relation between the two measures is an open question for future longitudinal and interventional studies.

As expected, correlations between performance on problems with and without a connection to reality and values were comparable for task-specific and task-unspecific scales as task-specific and task-unspecific measures refer to the same affective construct. Similar results were found for assessments of how performance is related to boredom, enjoyment, and interest (Schukajlow, 2015; Schukajlow & Krug, 2014).

The analysis of differences in correlations between problems with and without a connection to reality revealed that the type of problem is a significant factor that should be taken into account in future studies. Correlations between students' performance on real-world problems and students' task-unspecific values measured before or after task processing were higher than the respective correlations for intra-mathematical problems. Note that modelling problems were a significant part of the problems with a connection to reality used in this study. As these kinds of problems are not typical in mathematics classrooms, solving them might require a greater transfer of abilities than curricularly valid intra-mathematical problems. Because of this, the extent to which students value mathematics might be more strongly related of their performance on tasks with a connection to reality than on tasks without a connection to reality. A similar tendency was found for the relation between interest and performance on modelling and intra-mathematical problems (Schukajlow & Krug, 2014). Future studies are essential to investigate these findings further.

References

Bishop, A., Seah, W. T., & Chin, C. (2003). Values in Mathematics Teaching — The Hidden Persuaders? In A. J. Bishop, M. A. Clements, C. Keitel, J. Kilpatrick, & F. K. S. Leung

(Eds.), *Second International Handbook of Mathematics Education* (pp. 717-765). Dordrecht: Springer Netherlands.

Blum, W., Galbraith, P. L., Henn, H.-W., & Niss, M. (2007). *Modelling and applications in mathematics education. The 14th ICMI study*. New York: Springer.

Buff, A. (2014). Enjoyment of learning and its personal antecedents: Testing the change–change assumption of the control-value theory of achievement emotions. *Learning and Individual Differences, 31*(0), 21-29.

Efklides, A. (2006). Metacognitive Experiences: The Missing Link in the Self-Regulated Learning Process. *Educational Psychology Review, 18*(3), 287-291.

Guo, J., Marsh, H. W., Parker, P. D., Morin, A. J., & Yeung, A. S. (2015). Expectancy-value in mathematics, gender and socioeconomic background as predictors of achievement and aspirations: A multi-cohort study. *Learning and Individual Differences, 37*, 161-168.

Hannula, M. S. (2002). Attitude towards mathematics: Emotions, expectations and values. *Educational Studies in Mathematics, 49*(1), 25-46.

Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review, 18*, 315-341.

Rellensmann, J., & Schukajlow, S. (in press). Does students' interest in a mathematical problem depend on the problem's connection to reality? An analysis of students' interest and pre-service teachers' judgments of students' interest in problems with and without a connection to reality. *ZDM Mathematics Education*. doi:10.1007/s11858-016-0819-3

Schukajlow, S. (2015). Is boredom important for students' performance? In K. Krainer & N. Vondrová (Eds.), *Proceedings of the Ninth Congress of the European Society for Research in Mathematics Education* (pp. 1273-1279). Prag, Szech Republic: Charles University in Prague, Faculty of Education and ERME.

Schukajlow, S., & Krug, A. (2014). Are interest and enjoyment important for students' performance? In C. Nicol, S. Oesterle, P. Liljedahl, & D. Allan (Eds.), Proceedings of the Joint Meeting of PME 38 and PME-NA 36 (Vol. 5, pp. 129-136). Vancouver, Canada: PME.

Schukajlow, S., Leiss, D., Pekrun, R., Blum, W., Müller, M., & Messner, R. (2012). Teaching methods for modelling problems and students' task-specific enjoyment, value, interest and self-efficacy expectations. *Educational Studies in Mathematics, 79*, 215-237.

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental Psychology, 42*(1), 70.

Steiger, J. H. (1980). Tests for comparing elements of a correlation matrix. *Psychological Bulletin, 87*(2), 245.

Zan, R., Brown, L., Evans, J., & Hannula, M. S. (2006). Affect in Mathematics Education: An Introduction. *Educational Studies in Mathematics, 63*(2), 113-122.