DO TASK TYPE AND STUDY PROGRAM INFLUENCE MATHEMATICS STUDENTS' TASK EVALUATIONS REGARDING VALUES, COSTS, EFFORT, AND SELF-EFFICACY?

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Innovative tasks that specifically address connections between school mathematics and university mathematics have increasingly been implemented in university mathematics courses. Studies indicate that such tasks can strengthen prospective teachers' study motivation, but it is unclear whether they have the same effect on students not enrolled in a teaching program. In a study with 146 first-year students, we investigated whether students evaluated regular and innovative tasks differently regarding task values, costs, effort, and self-efficacy. We found significant moderating effects of the study program (teaching vs. non-teaching), indicating that innovative tasks were evaluated more favourably by prospective teachers, e.g., concerning utility value. These results suggest implementing specific tasks for students in different programs.

INTRODUCTION

School mathematics and university mathematics differ fundamentally in terms of their character and goals. While school mathematics emphasizes contextualized problem solving and intuitive access to concepts, university mathematics is taught as a formal, deductive discipline (Gueudet, 2008; Rach & Heinze, 2017). Consequently, many first-year students initially struggle to see connections between the mathematics they learnt at school and the mathematics they encounter at university – a phenomenon known as the first discontinuity. This issue is particularly significant for prospective teachers, who are expected to apply their university mathematical knowledge in their future teaching. However, they often struggle to transfer their knowledge to school contexts – a phenomenon known as the second discontinuity.

The challenging transitions between school and university have been the focus of research and practical initiatives in the past decades (e.g., Biehler et al., 2024; Wasserman et al., 2023). The reported challenges are particularly evident in contexts such as Germany, where prospective upper-secondary mathematics teachers traditionally attend the same university mathematics courses as students in non-teaching mathematics programs, prompting calls for course adaptations to accommodate different study programs. Regarding the specific challenge posed by the distinct character and goals of school and university mathematics, a frequently used intervention is the implementation of innovative tasks that explicitly address connections between school mathematics and university mathematics (e.g., Álvarez et al., 2020; Eichler & Isaev, 2023; Weber et al., 2023). In a study with 133 prospective

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teachers, students reported higher utility value for professional life and intrinsic value, as well as lower costs for innovative tasks than for regular tasks, supporting their potential (Rach & Schukajlow, 2024). However, it is unknown whether the results from a cross-sectional survey with embedded experimental manipulations can be replicated in a field context. Moreover, it remains an open question whether such task effects differ across study programs, as students in a non-teaching program are affected only by the first discontinuity, while students in a teaching program are likely to experience a double discontinuity. We address this gap by presenting a study that investigates how students across different study programs evaluate task types.

THEORETICAL FRAMEWORK

Expectancy-Value Theory

(Situated) expectancy-value theories are often used to describe educational choices and achievement, for example, the intensity with which a learning opportunity is used, by motivational factors (Eccles & Wigfield, 2020). Expectancies can be defined as "individuals' beliefs about how well they will do on an upcoming task" (Eccles & Wigfield, 2020, p. 3), often synonymously used with *self-efficacy*. Subjective task values describe how relevant or joyful learners assess a task to be. They can be divided into *intrinsic value* (How joyful is the task?), *attainment value* (How important is successfully engaging with the task for my identity?), and *utility value* (How important is the task for my goals?; Eccles & Wigfield, 2020). Rach and Schukajlow (2024) showed that, in the context of university education, it is meaningful to distinguish between *utility value for study program* and *utility value for professional life*, as students may evaluate tasks in relation to different goals, e.g., a task can be useful for passing a university exam but not useful for teaching school mathematics. *Costs* can be described as "perceived negative consequences of engaging in a task" (Gaspard et al., 2015, p. 664). In addition to evaluating expected value and cost, learners also decide how much *effort*, in terms of energy and time, they are willing to put in engaging with a task.

Interventions to Connect School and University Mathematics

Regular tasks in university mathematics courses represent standard university mathematics practices by focusing on abstract structures and formal proof techniques (Gueudet, 2008). *Innovative* tasks, in contrast, explicitly connect course content to the school context. These tasks may encourage the use of methods and representations from school mathematics to motivate or illustrate formal concepts from university mathematics. As another example, they may prompt students to explain the essence of a newly learned, advanced mathematical concept in a way suitable for school. For an exemplification of the tasks, see Figure 1. Teaching approaches that offer such innovative tasks vary in their goals which influence the design and implementation of these tasks: (1) *Building on prior knowledge – addressing the first discontinuity*: Initiatives that focus on the first discontinuity often provide their innovative tasks to

students who are in a teaching program as well as others, as they usually participate in the same academic mathematical courses at the beginning of their studies and struggle equally to draw connections between school mathematics and university mathematics (e.g., Álvarez et al., 2020). Corresponding tasks address university students as former school students and aim to enable them to build on their prior knowledge. (2) *Preparing for later profession – addressing the second discontinuity:* Initiatives that focus on the second discontinuity are usually especially designed for students in teaching programs, and the innovative tasks address them as future teachers (e.g., Eichler & Isaev, 2023). It is possible that these tasks also deepen university mathematical knowledge by connecting it to prior knowledge, making them useful for students not enrolled in a teaching program. However, acquiring university knowledge is not the specific goal of these tasks, but rather acquiring school-related content knowledge that can be used for classroom teaching. (3) *Supporting student motivation*: It is assumed that innovative tasks can support students to engage with the mathematical content more deeply because of superior motivational characteristics (e.g., subjective task value). In the study by Rach and Schukajlow (2024), for example, prospective teachers evaluated innovative tasks to have higher utility value for their future profession, yet lower utility value for their study program (Rach & Schukajlow, 2024).

Figure 1: Exemplary tasks (shortened for publication)

(Task 1, regular)

Let $f : (G, \circ) \to (H, *)$ be a group homomorphism. Prove the following statements:

a) If U is a subgroup of $(G, \circ)$, then $f(U)$ is a subgroup of $(H, *)$.

b) If V is a subgroup of $(H, *)$, then $f^{-1}(V)$ is a subgroup of $(G, \circ)$.

(Task 2, innovative)

a) Starting from the definition $\log_a(x) = b \Leftrightarrow a^b = x$, derive the rule $\log_a(x \cdot y) = \log_a(x) + \log_a(y)$ in a way suitable for 10th grade school students.

b) Using a), define an operation $*$ on $\mathbb{R}$ such that $f_a : (\mathbb{R}^+, \cdot) \to (\mathbb{R}, *)$, $f_a(x) = \log_a(x)$ is a bijective group homomorphism.

(Task 3, innovative)

Consider the following school definition: vectors $\vec{a}, \vec{b}, ...(\in \mathbb{R}^n)$ are called linearly independent if none of these vectors can be represented as a linear combination of the others.

a) Starting from the given school definition, prove using school mathematics that for two linearly independent vectors $\vec{a}, \vec{b} \in \mathbb{R}^n$, the vectors $\vec{a} + \vec{b}$ und $\vec{a} - \vec{b}$ are also linearly independent.

b) Show that the school definition is equivalent to the definition used in your lecture.

To our knowledge, no studies have systematically investigated the effects of innovative tasks in field settings among students not enrolled in teaching programs. Innovative tasks have been implemented in courses attended jointly by prospective teachers and students in non-teaching mathematical programs (e.g., Álvarez et al., 2020), and strong

theoretical arguments suggest that these students should also benefit from such tasks, but at the same time, varying goal orientations of future teachers and other mathematics students could systematically influence how they perceive tasks. To support further development of innovative tasks, empirical evidence on how students evaluate different types of tasks is therefore still needed.

RESEARCH QUESTIONS

Against this background, the present study addresses the following research questions:

RQ 1: Do students evaluate regular and innovative tasks differently with respect to task values, costs, effort, and self-efficacy?

We assume that students report higher self-efficacy and lower costs for innovative tasks compared to regular tasks, as innovative tasks explicitly build on students' prior knowledge.

RQ 2: Do prospective teachers and other mathematics students differ in their evaluations of regular and innovative tasks with respect to task values, costs, effort, and self-efficacy?

Since innovative tasks address prospective teachers' future professional practices, we assume that these tasks are associated with higher utility value for professional life, attainment value, and effort among prospective teachers than among other students.

METHODS

Context of the Field-Study

Innovative mathematical tasks were integrated into first-semester Linear Algebra courses at two German universities alongside standard coursework. As part of the evaluation, we designed an implementation study to investigate the effects and conditions under which the innovation is implemented.

Sample, Instruments, and Analysis Strategy

The study employed a within-subject, repeated-measures design to investigate whether students evaluate mathematical tasks of different types differently. A total of $N = 146$ first-semester students from two public universities in Germany participated. They were either enrolled in a mathematics study program designed for prospective upper-secondary teachers ($n = 83$) or other, non-teaching mathematical study programs ($n = 63$). Across four measurement occasions, participants evaluated a total of eight tasks, with two tasks presented at each occasion (one *regular* and one *innovative* task). The tasks were part of the regular weekly task sets used at both universities, and each pair addressed comparable subject matter from the course lectures. Task ratings were obtained during the students' main lectures in the second and third months of their studies using an online questionnaire based on expectancy-value theory, which assessed intrinsic value, attainment value, utility value (for study program vs. for professional life), costs, effort, and self-efficacy. All items were answered on a six-

point Likert scale ("1 – strongly disagree", "6 – strongly agree"). Table 1 provides an overview of the task-related motivational constructs surveyed.

Linear mixed models were fitted separately for each dependent variable to account for the nested structure of the data, including random intercepts for participants. For RQ 1, task type (regular, innovative) was included as a fixed factor. Explained variance (R^2) and model fits (χ^2) were evaluated in comparison to the intercept-only model. The specific task was not included as a random intercept, as task-level variance was non-significant across all dependent variables. For RQ 2, a fixed effect for study program and the interaction term of task type and study program were added, and incremental model fits were evaluated. All models were estimated with IBM SPSS Statistics (Version 31). This paper reports on the first, preliminary analysis of the data.

Table 1: Instruments, internal consistency, and means (*M*) and standard deviations (*SD*) across all tasks and participants

Scale (# items)	Example	Cronbach's α	Source	*M (SD)*
Intrinsic value (2)	I like the task.	.84 – .93	Gaspard et al. (2015)[1]	3.22 (0.88)
Utility value for study program (2)	This task addresses valuable topics for my studies.	.76 – .92	Rach & Schukajlow (2024)[1]	3.82 (0.96)
Utility value for professio-nal life (2)	This task addresses valuable topics for my future career.	.86 – .94	Rach & Schukajlow (2024)[1]	2.82 (0.94)
Attainment value (2)	This exercise is important to me.	.69 – .86	Gaspard et al. (2015)[1]	3.54 (0.96)
Costs (3)	Solving this exercise would exhaust me.	.68 – .86	Gaspard et al. (2015)[1]	3.52 (1.08)
Effort (2)	I would put effort into solving this task.	.72– .83	Dietrich et al. (2017)[1]	4.31 (0.91)
Self-Efficacy (2)	I am confident that I can solve this task.	.88 – .96	Hellwig & Geisler (2024)[1]	3.80 (1.10)

Notes: [1]adapted items; "1 – strongly disagree", "6 – strongly agree"

RESULTS

Differences by Innovative Tasks (RQ1)

The preliminary results of the linear mixed models indicate that the type of task had a differential effect on students' motivational beliefs. Innovative tasks were evaluated as having higher *utility value for professional life* (b = 0.90, p < .001) and, conversely, a significantly lower *utility value for study program* (b = -0,83, p < .001). Students attributed lower *attainment value* (b = -0.40, p < .001) and *effort* (b = -0.41, p < .001) to innovative tasks. In addition, task type contributed significantly to the explanation

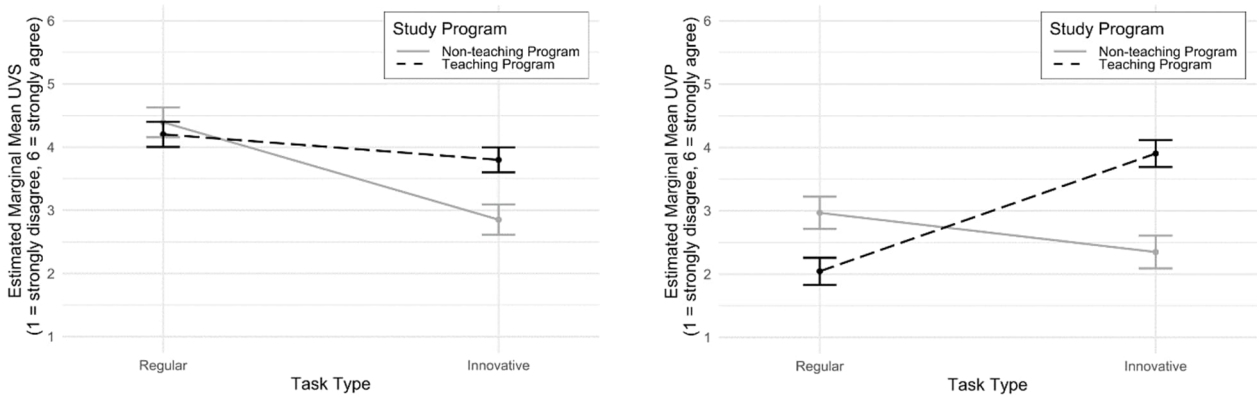
of variance in *self-efficacy* and *costs*, with innovative tasks being associated with higher *self-efficacy* (b = 0.48, p < .001) and lower perceived *costs* (b = -0.22, p < .001). No significant effect of task type was observed for *intrinsic value* (b = -0.60, p = .51). The marginal R^2_{mar} ranged from .08 for *costs* to .12 for *utility value for study program* and was therefore small to moderate.

Differences by Study Program and Innovative Tasks (RQ2)

Across all dependent variables, significant interactions between task type (regular versus innovative) and study program (teaching versus non-teaching) were observed (p < .001). The explained variance was small to medium (.04 < R^2_{mar} < .28).

Regular tasks were evaluated with comparable levels of *utility value for study program* across both study programs (b = -0.19, p = .22). In contrast, innovative tasks, received higher ratings in *utility value for study program* by prospective teachers than by students in other mathematics programs (b = 0.96, p < .001), reflecting a significant interaction between task type and study program (see Figure 1). Regarding the *utility value for professional life*, regular tasks were rated significantly lower among prospective teachers than among other students (b = -0.91, p < .001), whereas the opposite pattern emerged for innovative tasks (see Figure 1).

Figure 1: Estimated marginal means *of utility value for study program* (left) and *for professional life* (right) by task type and study program



Among students in non-teaching programs, innovative tasks received lower *intrinsic value* (IV), *attainment value* (AV), and *effort* (EF) ratings than regular tasks (IV: b = -1.00, p < .001; AV: b = -1.26, p < .001; EF: b = -1.08, p < .001). In contrast, among prospective teachers, *intrinsic value* (b = 0.53, p < .001) was higher for innovative tasks, while *attainment value* and *effort* remained descriptively stable across both task types. For *self-efficacy* (SE) and *costs* (C), the interaction effects favoured innovative tasks among prospective teachers compared to regular tasks (SE: b = 0.68, p < .001; C: b = -0.38, p < .001). Among students enrolled in non-teaching programs, no effects of task type were observed for either *self-efficacy* or *costs*.

DISCUSSION

The present study examined students' evaluations of mathematical tasks with respect to task values, costs, effort, and self-efficacy. The central aim was to investigate whether these evaluations differed by task types and study program, a question especially important contexts where students of different programs attend the same mathematics courses. Overall, innovative tasks were associated with lower costs and higher self-efficacy than regular tasks. In line with findings by Rach and Schukajlow (2024), the effects regarding costs were small but significant. Thus, innovative tasks may reduce uncertainty and support students' self-efficacy, presumably by explicitly addressing students' prior knowledge from school, which appears particularly relevant at the beginning of university studies. In addition, students reported lower attainment value and effort on innovative tasks than on regular tasks.

Differences between study programs provide us with further insights into innovative tasks. The lower attainment value for innovative tasks is primarily driven by students enrolled in non-teaching programs, who also, in line with expectations, rated these tasks as less useful for their future professional life. In contrast, prospective teachers attributed higher professional utility to innovative tasks, presumably because the explicit reference to school-related content and the teacher perspective establishes a clear connection to their future profession (cf. Eichler & Isaev, 2023; Weber et al., 2023). Unexpectedly, innovative tasks were rated as less useful for the study program across both groups, despite addressing central lecture content. This may be due to the instructional embedding of the tasks: regular tasks predominate in tutorials and assessments, whereas innovative tasks constitute only a small proportion of the overall task set. As a result, students may primarily associate regular tasks with aspects they consider central to academic success, largely independent of conceptual overlap.

The results should be interpreted in light of the following limitations. The analyses are based on data from a limited number of instructional contexts. Students' assessment of task values could also be influenced by the priority that lecturers or tutors implicitly or explicitly assign to different tasks, which we could naturally not control in this field study. Moreover, missing data, which should be accounted for in further detailed analyses, may have affected the findings.

In conclusion, this study provided valuable initial indications of differences in the evaluation of innovative, in contrast to regular, tasks across study programs. Prospective teachers evaluated innovative tasks more favourably across most motivational components, indicating that these tasks can achieve the intended effects of enhancing relevance perceptions and motivation in this group. However, the varied evaluation patterns across study programs suggest that – given the available resources – it is essential to carefully consider which tasks are allocated to which students, considering their distinct value attributions. Future studies may include experiments and planned contrasts across different study programs to deepen the understanding of

differential conditions and effects of task types, which is essential for the targeted design of innovative university mathematics courses.

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