

Fostering multiple document comprehension: motivational factors and its relationship with the use of self-study materials

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Abstract Multiple document comprehension (MDC) is an essential skill for university students, making it beneficial to improve it. We assume that the value assigned to MDC is important to foster MDC since it can be a predictor for behavioral choices, such as working with self-study material. Using self-study material is typical for university learning, but it requires the motivation to improve a skill such as MDC. We define motivation to improve MDC in terms of expectancy, value, and cost to improve MDC. We expect that it is a driving force for working with self-study material on MDC, while it might also depend on the perceived value of MDC. Therefore, this study examined whether the perceived value of MDC predicts the motivation to improve MDC, which is also expected to predict the use of self-study material. A total of 278 students of different majors participated in a MDC assessment and received the opportunity to train their MDC skill with self-study material. The engagement in using the self-study material was measured by the total time and the number of

Data, Material and/or Code availability The publication of the data on OSF is planned. The corresponding link will be submitted later.

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page transitions on the self-study material. The results indicated that the perceived value of MDC partially predicted motivation to improve MDC. However, further analysis revealed mainly no significant effects of the perceived value of MDC and the motivation to improve MDC on the engagement in using the self-study material. However, the log data indicated that the engagement in using the self-study material was not as high as expected.

Keywords Multiple document comprehension · Motivation · Value · Self-study material · Log data · Self-assessment

Förderung von Multiple Document Comprehension: Motivationale Faktoren und ihr Einfluss auf die Verwendung von Selbstlernmaterialien

Zusammenfassung Multiple Document Comprehension (MDC) ist eine wichtige Kompetenz für Studierende, weshalb ihre Verbesserung vorteilhaft ist. Wir nehmen an, dass der wahrgenommene Wert der MDC-Kompetenz wichtig bei der Förderung von MDC ist, da er ein Prädiktor für Verhaltensentscheidungen sein kann, wie z. B. die Bearbeitung von Selbstlernmaterialien. Die Bearbeitung von Selbstlernmaterialien ist typisch für das Lernen an Universitäten, erfordert aber die Motivation, sich in einer Kompetenz wie MDC zu verbessern. Wir definieren die Motivation, sich in MDC zu verbessern, als die Erwartung, den Wert und die damit verbundenen Kosten, sich in MDC zu verbessern. Wir nehmen an, dass die Motivation, sich in MDC zu verbessern, sowohl die Bearbeitung der Selbstlernmaterialien beeinflusst als auch von dem wahrgenommenen Wert der MDC-Kompetenz abhängt. Deshalb wurde in dieser Studie untersucht, ob der wahrgenommene Wert der MDC-Kompetenz die Motivation, sich in MDC zu verbessern, vorhersagt und letztere die Bearbeitung von Selbstlernmaterialien begünstigt. Insgesamt nahmen $N=278$ Studierende dreier deutscher Universitäten an einem MDC-Test teil und hatten danach die Möglichkeit, ihre MDC-Kompetenz mit Selbstlernmaterialien zu trainieren. Das Engagement bei der Bearbeitung der Selbstlernmaterialien wurde über die Bearbeitungszeit und die Anzahl der Seitenwechsel gemessen. Die Ergebnisse zeigten, dass der wahrgenommene Wert der MDC-Kompetenz die Motivation, sich in MDC zu verbessern, teilweise vorhersagte. Die weiteren Analysen zeigten im Wesentlichen keine signifikanten Effekte des wahrgenommenen Werts der MDC-Kompetenz und der Motivation, sich zu verbessern, auf das Engagement bei der Bearbeitung der Selbstlernmaterialien. Allerdings deuteten die ausgewerteten Log-Daten darauf hin, dass das Selbstlernmaterial nicht in dem erwarteten Umfang bearbeitet wurde.

Schlüsselwörter Multiple Document Comprehension · Motivation · Subjektive Wertzuschreibung · Selbstlernmaterialien · Log-Daten · Self-Assessment

1 Introduction

Multiple document comprehension (MDC) is an essential skill for students in higher education, making it beneficial for them to monitor their development in this skill and improve it if necessary. MDC enables students to successfully understand, represent, and integrate information from multiple texts on the same topic (Mahlow et al. 2020). As university students have to deal with information to study for an exam or to give a presentation autonomously, they need to determine whether the information across texts is redundant, complementary, or conflicting, and establish a coherent representation of who said what (e.g., Bråten et al. 2014). Studies have shown that many students have problems processing more than a single text (Britt and Rouet 2012). Therefore, fostering students' MDC should be part of university practices, for example, through targeted intervention (e.g., Britt and Aglinskas 2002; Stadler and Bromme 2008; Wiley et al. 2009). An important prerequisite for students to foster their MDC skill might be their perceived value of MDC since values are strong predictors of behavioral choices (Eccles 2005). In the university context, such behavioral choices might manifest in using self-study materials. Although self-study materials allow learners to choose when and where they learn, they also need self-regulated learning strategies to take control of the learning process. However, learners are not likely to engage in self-regulated learning without being motivated to process a task (e.g., Pintrich 1999; Schunk 2005). Therefore, using self-study material should also require the motivation to develop new skills or enhance existing skills.

Motivation is a critical construct in the context of learning. Following the expectancy-value framework (e.g., Wigfield and Eccles 2000), motivation is determined by the expectancy of being successful in a task, the value of engaging in this task, and the costs of engaging in this task (e.g., Barron and Hulleman 2015; Eccles and Wigfield 2020). Accordingly, we define the motivation to improve MDC in terms of the expectancy, value, and cost to improve MDC. We expect that the motivation to improve MDC is a driving force for working with self-study material on MDC and that the motivation to improve MDC depends on the perceived value of MDC. However, previous research did not examine the perceived value of MDC as a predictor for the motivation to improve MDC and their influence on behavioral choices regarding self-study material.

The present study explored whether students' perceived value of MDC predicts their motivation to improve MDC and their engagement in using the self-study material. The effects of the motivation to improve MDC on the engagement in using provided self-study material were also examined. We expected that the motivation to improve MDC serves as a mediator for the relationship between the perceived value of MDC and the use of self-study material. In the following, we provide a brief literature review of how to foster MDC and motivation in the context of MDC.

2 Theoretical background

2.1 Fostering multiple document comprehension

MDC is “the ability to construct an integrated representation of a topic based on several sources” (Schoor et al. 2020b, p. 221). Theoretical frameworks focusing on MDC, such as the RESOLV model (Rouet et al. 2017) or the MD-TRACE model (Rouet and Britt 2011), describe how readers learn from multiple documents. Two prominent frameworks are the Documents Model Framework (e.g., Britt and Rouet 2012) and the strategies identified by Wineburg (1991). The Documents Model Framework specifies the construction of a cognitive representation of multiple documents through a so-called documents model (e.g., Britt and Rouet 2012). The documents model is a mental model that consists of the integrated situation model and the intertext model. To build an integrated situation model, readers construct a representation of the contents of the documents in addition to their prior knowledge. The intertext model represents meta-information about the sources, for example: the author, form, goals, or cultural background (Perfetti et al. 1999). In group comparisons of individuals with different proficiency in MDC, several strategies have been identified that are beneficial in multiple document situations. Wineburg (1991) found that experts engaged more in sourcing, contextualization, and corroboration than novices when reading multiple documents. Sourcing includes taking information about the sources into account and is needed to construct an intertext model. To engage in contextualization, readers relate the information from the documents to their prior knowledge. Corroboration is reflected in comparing information across texts and helps develop an integrated situation model (Wineburg 1991).

MDC can be promoted through intervention (e.g., Britt and Aglinskas 2002). There are various approaches for different ages (e.g., Britt and Aglinskas 2002; Darowski et al. 2016; Wissinger and La Paz 2016) that largely focus on enhancing either content integration or sourcing, with a few concentrating on both aspects. Various interventions are also available in the university context, for example “met.a.ware” (Stadtler and Bromme 2008), “SOAR” (Daher and Kiewra 2016), or “SEEK” (Wiley et al. 2009). Although these interventions demonstrate their effectiveness in fostering MDC in experimental settings, their evaluation rarely considers the individual MDC skill of students before the intervention was carried out. Moreover, they take place in a rather controlled setting. The interventions are implemented as courses and/or students are proctored. In contrast, working with self-study material is not directed by a supervisor and does not require students’ attendance in a classroom, providing them with flexibility and autonomy about the circumstances of their learning. In this context, self-regulated learning is important because students take control of their own learning process. However, learners will not engage in self-regulated learning without motivation for the task (e.g., Pintrich 1999; Schunk 2005). Since the self-study material in the present study was not implemented in an experimental setting, we assume that, as a requirement of self-regulated learning, motivational factors might be critical for using the self-study material.

2.2 Motivation in the context of MDC

Perceived value is a motivational construct that refers to how much an individual wants to pursue a task and therefore is more likely to engage in certain behavior (e.g., Barron and Hulleman 2015; Eccles 2005). Values can be strong predictors for behavioral choices (Eccles 2005). Individuals can hold value for a task, such as using self-study material, for different reasons: The first is the intrinsic value which refers to the enjoyment and pleasure in performing a task. The second is the attainment value which refers to the perceived importance to do well on a task. The third is the utility value that refers to the usefulness of performing a task (Battle and Wigfield 2003). Hulleman (2007) focuses in particular on the utility-value and postulated in the utility-value process model that students who perceive material as useful are more engaged with it and feel more motivated. Accordingly, a high perceived value of MDC might be relevant for the motivation to improve MDC.

In line with the expectancy-value theory (e.g., Wigfield and Eccles 2000), the motivation to improve MDC refers to the expectancy to improve MDC, value to improve MDC, and costs to improve MDC. Expectancy can be defined as an individual's belief about how well they will perform on future tasks (Eccles et al. 1983). Even though ability beliefs are theoretically distinct from expectancies, they often overlap empirically (Eccles and Wigfield 1995). The value to improve MDC can be defined as the extent to which individuals value the improvement of MDC. When individuals value improving MDC, they are more likely to engage in that behavior (see Barron and Hulleman 2015). The last component is cost, which is "what the individual must give up to do a task [...] as well as the anticipated effort one will need to put into task completion" (Eccles 2005, p. 113). These costs are considered negative aspects of improving MDC that individuals experience.

Although the perceived value of MDC (utility value, attainment value, and intrinsic value) and the motivation to improve MDC (expectancy, value, and cost to improve MDC) are both motivational factors, they are different constructs. The perceived value of MDC focuses on the skill itself, especially regarding how useful, enjoyable, and important dealing with multiple texts is perceived. In contrast, the motivation to improve MDC refers to enhancing this skill, specifically the expectancy, value, and cost to improve MDC. The motivation to improve MDC means to actively engage in improving MDC, whereas the perceived value of MDC refers to the current value of this skill. Therefore, the constructs have different foci. We assume that students are more likely to want to improve a skill that they perceive as valuable. Therefore, the perceived value of MDC should predict the motivation to improve MDC.

Motivation is linked to students' choices about which learning tasks and activities to engage in and is, therefore, a predictor of engagement (e.g., Lazowski and Hulleman 2016). Engagement can also be considered as the manifestation of students' motivation (Schunk and Mullen 2012), as high motivation will find expression in students taking action. Engagement is a multidimensional construct that includes behavioral, cognitive, and affective attributes (Fredricks et al. 2004). Behavioral engagement reflects motivated action expressed in the quality of the participation in learning activities and student interactions with the learning materials, observable

as time or persistence (e.g. Skinner et al. 2008). It is evident that in the context of reading, intrinsic motivation and valuing contribute to behavioral engagement in terms of its quantity (e.g., amount of time, frequency of behavioral activities; for an overview, see Guthrie et al. 2012). Therefore, we assume that behavioral engagement is an indicator for the motivation to improve MDC. We consider the use of the self-study material as the behavioral manifestation of the motivation to improve MDC. Therefore, we assume that the motivation to improve MDC mediates the relation between the perceived value of MDC and the use of self-study material.

In tasks that may be perceived as effortful, such as MDC tasks (Hahnel et al. 2019b), learners need to be adequately motivated. Reading multiple documents demands more of readers than single text reading (Mahlow et al. 2020) because MDC depends on several cognitive skills and behaviors that are also affected by those skills (Hahnel et al. 2019b). Research on motivation in the context of MDC primarily focuses on motivational effects on reading and comprehending multiple documents (e.g. Barzilai and Strømsø 2018; Bråten et al. 2013; List and Alexander 2017). Within the context of a multiple text task, List et al. (2019) examined individual and situational interest as a motivational variable in association with indicators based on log data, such as the time on texts and number of accessed texts. They found it was situational interest, and not individual interest, that was associated with the time on texts. Situational interest had a greater effect on reading times than individual interest. Situational interest, prior knowledge, time on texts and number of accessed texts also predicted the performance on the multiple text task (List et al. 2019). However, previous research addressed the motivation of reading and comprehending multiple documents and presented interventions to improve MDC, but these studies did not address the relationship between motivational factors and the use of self-study material.

2.3 Present study

The present study examined whether the perceived value of MDC predicts students' motivation to improve MDC and use self-study material. The effects of the motivation to improve MDC on the engagement in using the self-study material were also examined. Additionally, we investigated the motivation to improve MDC as a mediator for the relationship between the perceived value of MDC and the use of the self-study material. In contrast to previous interventions, in this study, students assessed their MDC skill through a self-assessment with feedback (Schoor et al. 2020b) and subsequent self-study materials. We expected that students who rated the value of MDC higher are more likely to be motivated to improve MDC and show more engagement in using the self-study material. Therefore, we assumed that the motivation to improve MDC predicts the use of self-study material. Moreover, we considered the engagement in using the self-study material as the behavioral manifestation of the motivation to improve MDC. Therefore, the motivation to improve MDC might mediate the relation between the perceived value of MDC and the engagement in using the self-study material. This leads to the following hypotheses:

H1: Higher scores of the perceived value of MDC are related to higher scores in the motivation to improve MDC.

H2: Higher scores in the perceived value of MDC are related to more engagement in using the self-study material.

H3: Higher scores in the motivation to improve MDC are related to more engagement in using the self-study material.

H4: The motivation to improve MDC mediates the relationship between the perceived value of MDC and the engagement in using the self-study material.

Furthermore, to investigate whether the self-assessment with individual feedback and the recommendations for the self-study material worked as intended, we explored the use of self-study material by investigating the research questions: (How) Do students work with self-study materials? With which parts of the self-study material do they work in particular? Do students follow given recommendations about specific parts of the self-study material to work with?

3 Method

3.1 Sample

Participants were recruited through advertisements in university courses, e-mail, university social-media groups, and an obligatory seminar. Overall, 472 students registered for this study. 146 students were excluded from the sample because they did not start with the MDC test or had only missing data. One student was excluded from the sample due to a straightlining pattern in the questionnaire. We also excluded students who did not rate the perceived value of MDC, which was the first questionnaire scale in the study. The final sample consisted of 278 students of different majors (71% females, 81% master students, $M_{\text{age}} = 25.7$, $SD_{\text{age}} = 4.8$) from three German universities. However, the number of missing values differed for the variables due to outliers or not rated variables (further information is given in the Online Resource). Note that for the analysis of H3, we had to exclude some cases for the two variables that represented engagement (seven cases for time and six cases for page transitions), as those cases contained missing values on all relevant variables.

Most students were compensated for their participation with 15 to 25 € after finishing the second test in the winter semester 2021/22. During the course of the study, we increased the compensation because the recruitment during COVID-19 was challenging (further information is given in the Online Resource). The use of the self-study material was not compensated.

3.2 Design and procedure

The study was a correlational study. Before study participation, students were familiarized with the construct of MDC through a general introduction. Afterwards, they could register for the study and receive a password to log in to a learning management system (Moodle). The Moodle course provided a MDC self-assessment with individual automatic feedback and self-study material to promote MDC. After students provided their informed consent for participation, the study started with a tutorial and questions about demographic variables¹. Afterwards, the participants' MDC skill was assessed by a computer-based test (Schoor et al. 2020b). The participants were randomly assigned to one of two rotations in the MDC test which contained two units of the MDC test (see section Material and Instruments). A unit included multiple texts and items. Units not taken in the first measurement time point were presented at the second point of measurement.

Participants could take the test whenever they wanted and did not need to finish the test in one session. After taking the test, students rated the perceived value of MDC. After receiving automatically generated feedback, students rated their motivation to improve their MDC skill. The entire MDC assessment took about 1.5 to 2 h. Afterwards, students had the opportunity to train their MDC skill with self-study material. Participants were allowed to process the self-assessment from December 2020 to July 2021 and to work with the self-study material from December 2020 to November 2021. Throughout this time period, students were reminded about once a month that they had the opportunity to work with the self-study material.

We chose a natural setting instead of a laboratory setting because MDC is a generic cross-disciplinary competence that is equally relevant for students regardless of their major. MDC is not an explicit part of the academic curriculum. Therefore, students need to recognize deficits in this skill on their own and voluntarily train it. The self-assessment offered an opportunity to test and promote this skill autonomously and flexibly. Furthermore, the main purpose was to examine if and how such self-study materials can be transferred into the university context.

3.3 Material and instruments

3.3.1 MDC test with feedback

Students worked on the German MDC test as a self-assessment to assess their individual MDC skill (Schoor et al. 2020a, 2020b). The test consisted of different units, each including two or three texts with 11 to 17 items. The texts belonged to four different domains to assess MDC as a generic cross-disciplinary competence. Each item measured one of four cognitive requirements:

- Corroboration of information across texts
- Integration of information across texts

¹ Further variables were assessed before and after processing the assessment as well as after the feedback that were not relevant for this study.

- Comparison of sources and source evaluations across texts
- Comparison of source-content links across texts.

The MDC test represented a unidimensional construct, with an acceptable reliability (Hahnel et al. 2021; Mahlow et al. 2020; Schoor et al. 2020b). Item responses were given in a close-ended format, increasing the objectivity of the MDC test in administration and scoring. The validity of the MDC test score interpretation was examined by relating it to person characteristics (e.g., graduation grade) and characteristics of the comprehension process (e.g., indicators of corroboration and sourcing processes), and distinguishing MDC performance from related cognitive constructs (reading comprehension, reading speed, working memory; Hahnel et al. 2021; Mahlow et al. 2020; Schoor et al. 2020b). To represent MDC skill, we estimated person parameters with a Rasch model (weighted likelihood estimation, WLE) that used the item parameters of a scaling sample of 508 students of different majors (78% females, 53.3% bachelor students, $M_{\text{age}} = 22.8$, $SD_{\text{age}} = 3.8$; details reported in Hahnel et al. 2021; Mahlow et al. 2020).

After taking the MDC test, the participants received performance-based feedback and log data-based feedback. For the performance-based feedback, nine levels of feedback were defined based on Hartig's (2007) definition of competence areas, depending on what cognitive requirements students were able to master at a certain competence level (further information are given in Online Resource). For the log data-based feedback, collected log data was processed (e.g., button clicks or time stamps) using a finite state machine approach (Kroehne and Goldhammer 2018) to build process indicators that represented MDC-supporting strategies. The obtained indicators were used to provide students with up to two recommendations about which aspects they should practice with the self-study material.

3.3.2 MDC self-study material

After the MDC self-assessment, students had the opportunity to train their MDC skill with a digitalized learning tool, the self-study material. The self-study material was based on the task requirements of the test and feedback (Schoor et al. 2022). It consisted of an introduction, four content-related modules, and a transfer module (further information is given in Online Resource). The introduction provided information about the relevance of fostering MDC and an overview of the self-study material (4 pages). Module 1 focused on corroboration of information (39 pages), module 2 was about integration of information (14 pages), module 3 about comparing sources and source evaluation (17 pages), and in the last module students needed to combine source information and content information (10 pages). The transfer module provided information about how to use MDC for their studies (e.g., how to overcome obstacles; 5 pages). Students could either work on all modules or choose specific modules, for example, based on the feedback recommendations. The self-study material could be closed and started at any time, and students could navigate back and forth between the pages. In the beginning, the material provided an introduction about the relevance of promoting MDC. Afterwards, participants could choose between the four modules and the transfer module. Each module (except the

Table 1 Number and percentage of students categorized as engaged with the self-study material

Variable	No engagement	Engagement	Missing (Outliers)
Time on the self-study material	85 (30.6%)	152 (54.7%)	41 (14.7%)
Page transitions in the self-study material	93 (33.5%)	149 (53.6%)	36 (12.9%)

Note: Total sample size is $n = 278$. Outliers were deleted and created missing values. Outliers were characterized, for example, by unrealistically large time values

transfer module) started with an instructional sequence and then provided multiple documents with subsequent questions about the texts. The accuracy of an answer could be checked by clicking on a “Feedback”-button. If the answer was wrong, students could correct their answer and receive feedback again. Module 2 additionally offered hints for task solutions.

During working with the self-study material, event-based log data of each participant were collected, such as time data and button clicks. In the present study, we used time and page transitions as indicators of engagement in using the self-study material. The time on the self-study material and the number of page transitions were assessed when students accessed the self-study material, beginning with the introduction pages. The time scores and number of page transitions of students who did not access the self-study material were set to zero. For students who did access the self-study material, the *time on the self-study material*, was determined as the summed up time differences between single log events. Students needed to engage with the self-study material for at least one second (rounded up on one second). However, some students stayed in the self-study material for a long time without interacting with it. Thus, we assumed that these students abandoned the self-study material or did not work on it properly. Because this could bias the time measure, we excluded time differences between log events greater than 387 seconds. This value is motivated by the assumption that the average processing time per page of the self-study material is about 300 to 400 seconds, since some pages contained long texts or complex tasks with feedback. Examining the percentiles of the total time on the self-study material revealed that the 70% percentile is 387 seconds. This is in line with our theoretical assumption and was, therefore, used as criterion for the time differences. Further, we used boxplots and interquartile ranges to identify outliers. We identified 41 outliers and set the time score of the outliers on missing.

To assess the *number of the page transitions*, button clicks of switching to a new or previous page were counted and summed up to an overall score. We started counting the button clicks when students switched from the first introduction page to the second introduction page. Again, we used boxplots and interquartile ranges to identify outliers. We identified 36 outliers and set the page transition score of them on missing.

Table 1 shows the number and percentage of students who accessed the self-study material (including the introduction pages) and therefore had scores greater than zero on the time and page transitions. Participants who did not engage with the self-study material had scores of zero. Outliers were not included in the analyses. The number of students with a time and page transition score differed. Students might have only time or page transition scores because they did not switch the first introduction page

or they were on the material for under one second. Overall, 134 students had a score for both variables, and the other students either had a time score ($n = 18$) or a page transition score ($n = 15$).

To examine the explorative research questions, the following additional indicators were built: An indicator for the number of different modules visited (ranging from 0 to 5) and dichotomous indicators of having accessed each module. Afterwards, these indicators were compared with students' individual MDC recommendation by filtering the sample in nine subsamples based on the individual feedback level.

3.3.3 Perceived value of MDC

The perceived value of MDC was assessed by means of an adapted scale by Steinmayr and Spinath (2010) with three items for three dimensions (attainment value, utility value and intrinsic value) on a 5-point Likert scale. Confirmatory factor analysis (CFA) yielded an inadequate model fit ($\chi^2 = 144.614$, $df = 2$, CFI = 0.93, TLI = 0.90, RMSEA = 0.13, SRMR = 0.08; Schermelleh-Engel et al. 2003). Since the model could not be substantially improved with theoretically sensible model modifications, we split the model into random halves and analyzed half of the data by conducting an explorative factor analysis (Sample A; $n = 140$). A two-factor measurement model with five items replicated well on sample B ($n = 139$, $\chi^2 = 14.806$, $df = 5$, CFI = 0.98, TLI = 0.96, RMSEA = 0.12, SRMR = 0.06) as well as on the whole sample ($\chi^2 = 12.999$, $df = 5$, CFI = 0.99, TLI = 0.98, RMSEA = 0.08, SRMR = 0.04). After the changes, there was no longer an indication of attainment value, whereas the intrinsic value of MDC was represented by three items (e.g., "Dealing with multiple texts is interesting."; $\omega = 0.90^2$) and the utility value of MDC by two items (e.g., "Dealing with multiple texts is useful for my studies"; $r = 0.83$). Arguing that attainment value can only be perceived after sufficient experience with a task and not immediately upon task engagement (e.g., Hulleman 2007), it might be acceptable that attainment value was excluded due to an inadequate model fit.

3.3.4 Motivation to improve MDC

The motivation to improve MDC was measured with an adapted and translated version of the "Expectancy-Value-Cost" questionnaire by Barron et al. (2017), with three items for expectancy, three items for value, and four items for cost on a 5-point Likert scale. A CFA with three factors yielded an inadequate model fit ($\chi^2 = 101.671$, $df = 32$, CFI = 0.90, TLI = 0.86, RMSEA = 0.11, SRMR = 0.08). Therefore, we split the sample. Modifications in Sample A ($n = 99$) were cross-validated in Sample B ($n = 99$, $\chi^2 = 22.592$, $df = 18$, CFI = 0.99, TLI = 0.98, RMSEA = 0.05, SRMR = 0.06). The changes resulted into an acceptable model fit ($\chi^2 = 33.634$, $df = 18$, CFI = 0.97, TLI = 0.96, RMSEA = 0.07, SRMR = 0.04). After the modifications, expectancy to improve MDC was represented by two items (e.g., "I know I can improve in dealing with multiple texts."; $r = 0.54$), the value to improve MDC by three items (e.g.,

² Since Cronbach's α often present no ideal measure of internal consistency, it was quantified by McDonalds ω (Dunn et al. 2014).

“I think it’s important to improve in dealing with multiple texts.”; $\omega = 0.89$) and costs by three items (e.g., “I am not able to spend enough time to improve in dealing with multiple texts.”; $\omega = 0.66$).

3.3.5 Feedback usefulness

Feedback usefulness was used for a manipulation check to examine how students perceived and interpreted the feedback. After participating in the MDC assessment and receiving feedback, students rated the perceived usefulness of the feedback on a 5-point Likert scale. We used an adapted scale with four items by Bürgermeister et al. (2011). Students were asked whether the feedback has helped them to recognize how they can improve their MDC skill (e.g., “The feedback helps me to see where I can still improve”; $\omega = 0.92$).

All items are provided in the Online Resource.

3.4 Data analysis

All analyses were conducted using Mplus 8.6 (Muthén and Muthén 2017). To define the indicators for the self-study material use, the software R 4.1.0 (R Core Team 2021) and the R package *LogFSM* (Kroehne and Goldhammer 2018) were used. Missing values were handled by full-information maximum likelihood (FIML; Enders 2010). Utility value and intrinsic value of MDC as well as expectancy, value, and cost to improve MDC were modelled as latent variables in each model. For H1, latent regression analysis was conducted with the perceived value of MDC predicting the motivation to improve MDC. Maximum likelihood (ML) estimation with robust standard errors was used.

In order to investigate H2 and H3, we applied regression models for zero-inflated count data (Lambert 1992). Zero-inflated count models can deal with excessive zero values in count variables by assuming that data are based on a mixture of two separate data-generating processes. These processes encompass 1) one binary choice process and 2) a process leading to the outcome conditioned on the binary response. A Bernoulli trial determines which of the two processes generates an actual observation. In our case, the first data-generating process referred to either visiting the self-study material or not. The second data-generating process related to the size of the variable meant to measure engagement with the self-study material. To obtain a proxy for engagement with the self-study material, we used the number of page transitions inside the self-study material and the total time spent on the self-study material in seconds as dependent variables. Note that to apply the presented model to the total time spent, we discretized the time variable by rounding it to the nearest second. Finally, to decide if the models had to be conducted with a Poisson or Negative Binominal distribution, we studied the dispersion of the outcome variables. The dispersion of both variables (time and page transition) showed that the variances are larger than the means. This difference indicated overdispersion for the outcome variables; therefore, we used zero-inflated Negative Binominal Regressions. In order to evaluate H4, two mediation models were defined with the motivation to improve (i.e., expectancy, value, and cost to improve MDC) as mediator for the relation

between the perceived value of MDC (i.e., utility value and intrinsic value) and the time (Model 1) as well as the page transitions in the self-study material (Model 2).

4 Results

4.1 Descriptive statistics and the use of self-study material

Table 2 reports descriptive statistics for the variables included in the hypotheses. Compared to the scaling sample with an average MDC skill of zero (Hahnel et al. 2021; Mahlow et al. 2020), the average MDC skill of our sample was lower ($M = -0.16$) implying that there was room for improvement. The rated feedback usefulness indicated that students perceived the feedback as helpful to recognize how to improve their MDC skill ($M = 3.58$). In-detail analyses of students' use of the self-study material revealed that at least the first introduction page was accessed by 167 of the 278 students (60.07%)³. Time and page transitions in the self-study material were positively correlated. Furthermore, the correlation of utility value with value to improve MDC ($r = 0.25$, $p < 0.001$), expectancy to improve MDC ($r = 0.32$; $p < 0.001$), and cost to improve MDC ($r = -0.25$; $p < 0.001$) were low. Intrinsic value was not significantly related to expectancy ($r = 0.12$; $p = 0.09$) or value ($r = 0.02$; $p = 0.76$) to improve MDC and lowly correlated with cost to improve MDC ($r = -0.27$; $p < 0.001$).

Table 3 shows how many of the 167 students accessed the different modules, how many students received a recommendation for a module, and whether students accessed a module after they had received the recommendation in the feedback. Modules were recommended in a varying frequency (further information are given in Online Resource). The transfer module was not recommended in the feedback because it is beneficial for all students. Of the 278 students in the sample, 167 accessed at least the first introduction page, $n = 43$ students accessed only one module, $n = 16$ students accessed two modules, $n = 3$ students accessed three modules, no student accessed four modules, and $n = 1$ student accessed all content-related modules and the transfer-module. Therefore, 37.72% of the 167 students accessed at least one module. On average $M = 0.52$ ($SD = 0.82$) modules were accessed of the 167 students.

4.2 Perceived value of MDC and motivation to improve MDC (H1)

We investigated whether the perceived value of MDC can predict the motivation to improve MDC. Figure 1 shows the regression model ($n = 278$, $\chi^2 = 94.303$, $df = 57$, $CFI = 0.98$, $TLI = 0.97$, $RMSEA = 0.05$, $SRMR = 0.05$) for the relationship between the perceived value of MDC and the motivation to improve MDC. Higher scores in the utility value of MDC predicted higher scores in the expectancy to improve MDC ($\beta = 0.45$; $p < 0.001$) and the value to improve MDC ($\beta = 0.37$; $p < 0.001$) as well as lower perceived cost to improve MDC ($\beta = -0.24$; $p = 0.02$). The intrinsic value of MDC was only negatively related to the costs to improve MDC ($\beta = -0.22$; $p = 0.02$).

³ The 167 students who accessed the self-study material had a time and/or page transition score.

Table 2 Means, Standard Deviations, and Correlations for the Manifest Variables

Variable	<i>N</i>	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8
1. MDC skill	278	-0.16	0.77	-	-	-	-	-	-	-	-
2. Utility value of MDC	276	4.4	0.78	0.21**	-	-	-	-	-	-	-
3. Intrinsic value of MDC	278	3.29	0.90	0.21**	0.39**	-	-	-	-	-	-
4. Feedback usefulness	198	3.58	0.94	-0.08	0.18*	-0.02	-	-	-	-	-
5. Expectancy to improve MDC	195	3.80	0.76	0.11	0.32**	0.12	0.52**	-	-	-	-
6. Value to improve MDC	194	3.73	0.91	-0.00	0.25**	0.02	0.58**	0.57**	-	-	-
7. Cost to improve MDC	196	2.96	0.86	-0.17*	-0.25**	-0.27*	-0.00	-0.21**	-0.05	-	-
8. Time on self-study material (in sec)	237	36.92	55.55	-0.01	-0.04	-0.03	0.06	-0.05	-0.03	-0.09	-
9. Page transitions in the self-study material	242	3.12	4.34	0.06	0.02	-0.01	0.11	0.05	0.11	-0.08	0.64**

* $p < 0.05$; ** $p < 0.01$

Table 3 Accessed modules in the self-study material

	Module 1	Module 2	Module 3	Module 4	Transfer Module
Number of students who accessed the module	25	13	6	15	30
Number of students who received a recommendation for the module	63	50	93	104	–
Number of students who accessed the module after recommendation	9	7	4	14	–

Note: Students received up to two recommendations in the feedback

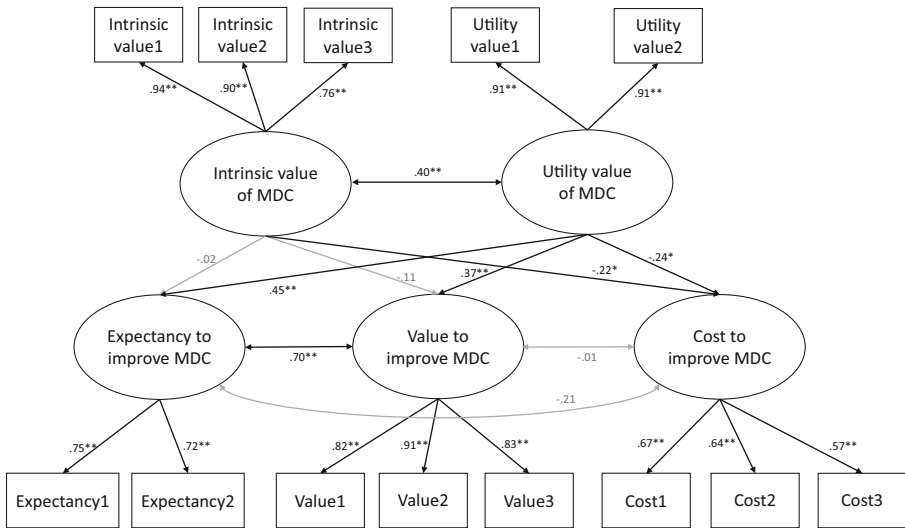


Fig. 1 Latent regression analysis with perceived value of MDC and motivation to improve MDC * $p < 0.05$, ** $p < 0.001$

4.3 Perceived value of MDC and use of the self-study material (H2)

We explored whether the perceived value of MDC predicts the use of the self-study material with two zero-inflated negative binomial regression models, analyzing the effects of the perceived value of MDC on time spent on and the number of page transitions in the self-study material. Concerning time spent on the self-study material, the model showed that neither utility value ($\beta = 0.04$; $p = 0.71$) nor intrinsic value ($\beta = -0.01$; $p = 0.93$) significantly predicted the first data-generating process of spending time on the self-study material or not. The second process addressing the amount of time spent on the self-study material was also not predicted by the utility value ($\beta = -0.02$; $p = 0.88$) and the intrinsic value ($\beta = -0.05$; $p = 0.57$).

The model predicting page transitions as the dependent variable showed similar results. There were no significant effects of the perceived value of MDC on predicting whether students would access the self-study material or not (utility value: $\beta = -0.13$; $p = 0.29$; intrinsic value: $\beta = -0.05$; $p = 0.71$) or how many page transitions

they perform in the self-study material (utility value: $\beta = -0.02$; $p = 0.87$; intrinsic value: $\beta = -0.07$; $p = 0.51$).

4.4 Motivation to improve MDC and use of the self-study material (H3)

We investigated whether the motivation to improve MDC predicts the use of the self-study material with two zero-inflated negative binominal regression models, analyzing the effects of the expectancy, value, and cost to improve MDC on time spent on and the number of page transitions in the self-study material. Concerning time spent on the self-study material, students' motivation to improve MDC did not predict the first data-generating process of spending time on the self-study material or not (expectancy: $\beta = 0.05$; $p = 0.87$; value: $\beta = -0.08$; $p = 0.74$; cost: $\beta = -0.25$; $p = 0.15$). The second process determining the amount of time spent on the self-study material was also not predicted by expectancy ($\beta = -0.97$; $p = 0.11$) and value ($\beta = 0.34$; $p = 0.66$). However, cost to improve MDC was negatively related to the amount of time spent on the self-study material ($\beta = -1.01$; $p < 0.001$)⁴.

The model predicting page transitions as the dependent variable showed similar results. There were no statistically significant effects of students' motivation to improve MDC on predicting whether students would access the self-study material or not (expectancy: $\beta = -0.11$; $p = 0.73$; value: $\beta = -0.07$; $p = 0.81$; cost: $\beta = -0.26$; $p = 0.17$) and partly on the number of page transitions (expectancy: $\beta = -0.80$; $p = 0.24$; value: $\beta = 0.87$; $p = 0.15$). However, perceived costs to improve MDC was significantly related to the number of page transitions ($\beta = -0.98$; $p < 0.001$).

4.5 Mediation analysis (H4)

The regression analyses revealed no statistically significant effects, thus not meeting the requirements for mediation analyses. Therefore, we did not specify mediation models with the motivation to improve (expectancy, value and cost to improve MDC) as mediator for the relationship between the perceived value of MDC (i.e., utility value and intrinsic value) and the engagement in the self-study material (time, page transitions).

5 Discussion

The main purpose of this study was to examine the relation between the perceived value of MDC, motivation to improve MDC and the use of the self-study material. In detail, we investigated whether the perceived value of MDC affected the motivation to improve MDC as well as the engagement in using the self-study material. We further explored the effects of the motivation to improve MDC on the engagement in using the self-study material. In a last step, the mediating role of the motivation to improve MDC on the relation between the perceived value of MDC and the

⁴ The standardized coefficient over one is due to the way of the standardization.

engagement in using the self-study material operationalized through the overall time and the number of page transitions was examined.

5.1 Discussion of the results

We used adapted scales for measuring motivational factors of MDC based on the expectancy-value framework. Although the perceived value of MDC and the motivation to improve MDC are both motivational variables, they differ in their focus. The utility value and the intrinsic value of MDC itself can be assumed to influence the expectancy, value, and costs to improve MDC differently. The correlations of the subscales of the perceived value of MDC with the expectancy, value, and cost to improve MDC were not very high, indicating that the motivational variables measured different constructs. Therefore, we examined the effects of the perceived value of MDC on the expectancy, value, and cost to improve MDC. The perceived value of MDC partially predicted the motivation to improve MDC (H1). Higher utility values of MDC led to a higher motivation to improve MDC (expectancy, value, and cost) whereas students with higher intrinsic value of MDC perceived only lower costs to improve MDC compared to students with a low intrinsic value. Therefore, our findings could imply that especially utility value may be of particular importance for the motivation to improve MDC. Other research has also postulated the particular importance of utility value for motivation and performance in educational outcomes (e.g., Simons et al. 2004). Future research should also explore effects of the perceived value of MDC on the performance in MDC.

With regard to H2 and H3, the perceived value of MDC and the motivation to improve MDC did not influence students' access of the self-study material. Neither the perceived value of MDC nor expectancy and value components of students' motivation to improve MDC predicted the total time and the page transitions in the self-study material. However, the analyses revealed that the cost to improve MDC was negatively related to the time spent on the self-study material and amount of page transitions made while accessing it. The finding indicated that students who perceived lower costs to improve MDC were more willing to engage with the self-study material. Research confirms that students' perception of costs negatively predicts educational outcomes such as course-taking intentions or choices (e.g., Battle and Wigfield 2003).

Concerning the mediation hypothesis (H4), we refrained from the planned analysis because there was no relationship between the perceived value of MDC and the use of the self-study material, which would have been a prerequisite for a meaningful mediation model. Accordingly, we could not investigate hypothesis H4 for our study.

To explain these results, exploring the actual use of the self-study material might be beneficial. Descriptive statistics indicated that students highly rated the utility value of MDC, the intrinsic value of MDC, and the motivation to improve variables. Therefore, it can be assumed that these high values also lead to engagement. However, examining the actual use of the self-study material indicated that most students did not access the self-study material or work with it intensively. Considering that the self-study material contained an introduction and five different modules, includ-

ing texts, questions, and feedback, the average time ($M = 36.92$ sec., $SD = 55.55$) and the average number of page transitions ($M = 3.12$, $SD = 4.34$) were extremely low. Accordingly, it seems plausible that most students, who accessed the self-study material, just opened the material and clicked through the first pages without working with it in a concentrated way. Through zero-inflated count models, we could closely examine this lack of use by investigating the effect of the motivational variables on whether they predict access (first process) and engagement in the self-study material (second process). The results of the first process indicated that neither the perceived value of MDC nor the motivation to improve MDC affected students' choice to access the self-study material. Although students might value MDC skills and their improvement, the motivation was not enough to engage in the presented learning opportunity to improve their MDC skills. The results of the second process extended this picture: If students accessed the self-study material, a highly rated perceived value of MDC, expectancy, and value to improve MDC did not result in more engagement on the self-study material. However, the perceived cost to improve MDC was negatively related to the engagement in the self-study material. That means, if students engaged in the learning opportunity, they were more likely to keep up their learning efforts when their perceived costs to improve MDC were lower. This is in line with the assumption that most students just opened the material, clicked through the first pages, and recognize that it takes too much effort to work with the self-study material.

Different possible explanations could apply. Self-regulated learning is important for working with self-study material. However, learners will not engage in self-regulated learning without motivation for the task (e.g., Schunk 2005). Even though students in the present study seemed to be motivated, they might have struggled with self-regulated learning. Participants might not have engaged in self-regulated learning strategies and therefore could not work with the self-study material intensively. Therefore, future research should assess self-regulated strategies (e.g., with log data or self-reports) when working with MDC self-study material.

Furthermore, the characteristics of the self-study material might have influenced the participants' use of the self-study material. It might be the case that the students opened the self-study material and immediately closed it because it seemed not helpful enough or appeared not educational or pleasant. Therefore, future research could also collect qualitative data in terms of interviews. Students may be asked, why or why not they worked with the self-study material to get insights into the students' motivational behavior. Furthermore, the appearance and effectiveness of the self-study material as well as the motivation to improve MDC after opening the self-study material could be examined.

Alternatively, the lack of extrinsic influence or incentive might have affected students' work with the self-study material. Participants received an incentive for finishing the MDC self-assessment twice but not for the use of the self-study material. Although students expressed a high utility value, they rated intrinsic value not that high. This result indicated that students' intrinsic value of MDC (or their intrinsic motivation) might be too low to access or work with the self-study material intensively or that a high utility value might not be enough to promote action. Alternatively, the utility value might be interpreted as an evaluation of the usefulness

of the MDC skill. That means, students might be aware that their MDC skill is important for their academic success, although not reflected in the intrinsic value. Moreover, students did not receive an extrinsic incentive to compensate for the low intrinsic value or had an outside pressure, for example, through teachers. This leads to the question: Who is responsible for the development or improvement of MDC? On one hand, it may be the task of the students' themselves to achieve better grades or a successful graduation. On the other hand, it might be the responsibility of the universities or teachers in terms of enhancing intrinsic motivation to participate. Therefore, in future studies the self-study material could be implemented in a university course, or the academic curriculum. Since MDC is an important competence for university students that should be trained (e.g., Schoor et al. 2020b), teachers or student advisors should direct attention to the importance of MDC and advise students to train their MDC skill. Thus, teachers or students' advisors should make the contents more relevant for the study progress.

5.2 Limitations

The first limiting factor concerns the sample of this study. The sample mainly consisted of master students who worked in the context of an obligatory seminar on the first MDC test. Moreover, all students received an incentive of up to 25 € for processing the MDC test twice. That means, the intention of the students was not necessarily to assess and improve MDC. This could indicate a potential bias of the results in this study and also influence the use of the self-study material. Since these students finished their task in the seminar or received the incentive by completing only the MDC tests, they might not have seen the necessity to use the self-study material. Thus, it might also be a methodological problem for measuring motivation constructs and engagement when students were rewarded. Further research should examine if students who were paid for participation behaved differently.

Additionally, many students did not access the self-study material. To consider students' behavior of accessing the self-study material or not, we used zero-inflated count models. However, future research should further examine the effects of the motivational variables on the engagement variables with more participants who work with the self-study material in an engaged way. A possible way to reach this goal might be to implement the MDC test and self-study material in cross-disciplinary courses or to make it part of the students' general curriculum in Germany. Furthermore, teacher and students' advisors should draw attention to this important skill and advise students to improve it.

Another limitation might concern the feedback component of the MDC assessment. The students might feel that the feedback was good enough and therefore did not need to improve their MDC skill. Moreover, future research should address the effectiveness of the self-study material.

As another limitation should be mentioned that the perceived value of MDC and the motivation to improve MDC were both understood and measured by means of the expectancy-value model (e.g., Eccles and Wigfield 2020). Therefore, the similarity of the constructs might be a methodological artifact. This could have influenced the effects of the perceived value of MDC on the motivation to improve MDC.

Although the perceived value of MDC and the motivation to improve differ in their focus, participants might not have noticed this difference and therefore rated the constructs similar. Furthermore, the scales to measure perceived value of MDC and motivation to improve MDC were significantly adapted and changed to get an acceptable model fit.

Finally, we analyzed log data and defined specific indicators (Kroehne and Goldhammer 2018) to derive behavioral metrics on the use of the self-study material (e.g., time, page transitions). These metrics were interpreted to represent the engagement of working with the self-study material. While we considered the defined indicators as appropriate measures for the engagement for the use of the self-study material, this approach carries some limitations. In order to operationalize behavioral engagement in online environments some studies used log data of users' activity within a system, such as a click or page view counts or time spent on action (e.g., Henrie et al. 2018). However, spending more time or having more activity in a learning environment does not necessarily imply positive student engagement (Henrie et al. 2018). Thus, by only analyzing log data we cannot make a statement about the actual concentrated working time. Therefore, the interpretation of indicators from log data requires validation (Hahnel et al. 2019a). Nevertheless, we tried to figure out the actual working time by excluding time differences that indicated inactivity. Furthermore, we defined another indicator to explore the interactions with the self-study material by page transitions. Although, we considered the indicators as appropriate measures for the use of the self-study material, future research should take other factors into account and examine combined or more complex indicators. Furthermore, the interpretations of the indicators should be validated with other measures (e.g., interviews).

6 Implications for university practices

Based on the findings in this study, we can derive implications for university practices. Students usually need to read multiple documents to study for an exam, give a presentation, or write a term paper. Fostering students' MDC skill should be a part of university practices because research shows that many students have problems processing multiple texts (Britt and Rouet 2012). The results of this study indicated that students perceive MDC as a relevant and useful skill for their studies and state a willingness to improve it. However, although they had the opportunity to improve their MDC skill, students rarely did take advantage of the offer. As an implication for university practices, teachers and student advisors might draw attention to this important skill and address it in their courses. University teachers could try to enhance the intrinsic motivation of the students to foster MDC, for example, by implementing the self-study material as part of their courses, making the MDC skill relevant for the study progress of their students. Another possibility to address this issue might be to implement the self-assessment in the academic curriculum, introductory courses or courses for scientific work. In this regard, the self-assessment provides an offer for students to improve their MDC skill and it should be examined where and how the MDC assessment can be implemented.

7 Conclusion

Our findings highlight that the perceived value of MDC partially predicted the motivation to improve MDC. Especially utility value of MDC was of great importance for the motivation to improve MDC. However, analyses regarding the use of the self-study material as a digital learning tool revealed almost no significant results. Our findings point out that the self-study material was not accessed or used intensively. Possible reasons might be a lack of self-regulated learning strategies or missing extrinsic incentives. Nevertheless, students seemed to recognize the importance of MDC because they are probably confronted with multiple texts from several sources in their studies. However, future research should address the following questions: How do students recognize the importance to actively foster MDC? Why did students not use the self-study material? How do we engage students more in using self-study material? Do they need more extrinsic incentives to use self-study material? Moreover, it should be explored whether the use of the self-study material leads to better performance and more strategy use. Nevertheless, it is necessary to provide students with learning opportunities, such as self-study material for further development.

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Declarations

Conflict of interest T. Zink, C. Hahnel, U. Kroehne, T. Deribo, N. Mahlow, C. Artelt, F. Goldhammer, J. Naumann and C. Schoor declare that they have no competing interests.

Ethical standards The project “MultiTex-Transfer” was reviewed by the Ethics Comitee of the University of Bamberg, Germany, and an approval granted. *Consent:* Students provided their informed consent for participation, before processing the assessment.

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