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The autonomy-enhancing effects of choice on cognitive load, motivation and learning with digital media

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ABSTRACT

According to the Self-Determination Theory, the autonomy-supporting feature of choice leads to an increase in intrinsically motivated behavior. Although this effect was replicated multiple times, instructional designers often dread to include choice options in single tasks because of the high effort in designing additional materials or a higher cognitive load for students. This study used a *feigned choice paradigm* to avoid additional efforts for designers. Moreover, this study examined the mediational influences of learners' perceived autonomy and intrinsic motivation on choice effects and the moderating influence of the *relevance of choice options*. In Experiment 1, 79 secondary school students were randomly assigned to either a group with a feigned topic choice or a group without the possibility to choose. Results show that both retention and transfer performance (learning scores) were enhanced by choice options. In addition, the effect of choice on retention was mediated by perceived autonomy but not by intrinsic motivation. In Experiment 2, 87 secondary school students were assigned to a 2 (with or without a feigned learning-relevant choice) x 2 (with or without a feigned learning-irrelevant choice) design in order to additionally examine the moderating effects of relevance of choice options. All results of Experiment 1 were replicated for the inclusion of learning-relevant choices, whereas irrelevant choices were not found to significantly impact scores of transfer and external regulation. Interestingly, all students with a choice reported a lower intrinsic load, although the complexity of the learning tasks was kept constant.

1. Introduction

New technologies often promise an individualization of learning processes. However, when reading tasks are presented to learners at computers, their motivation to join and keep working on tasks can fade quite rapidly. In this context, highly motivated learners tend to keep working longer than learners with a low motivation (Martens, Gulikers, & Bastiaens, 2004). For this, specific design principles enhancing a learner's motivation during tasks are needed. According to the *self-determination theory* (SDT; Deci, 1980; Ryan & Deci, 2000), features enhancing the students' perception of competence, relatedness or autonomy can help to increase the motivation to learn. In computer-based environments, limited choice options, as one component to increase the feeling of autonomy, was found to be a main problem (Hartnett, 2015). In conclusion, providing choice might be a powerful tool for educators to increase a learner's autonomy in task-specific behavior and finally his or her motivation to engage in learning. Indeed, motivation-enhancing effects of choice received multiple empirical (e.g., van Loon, Ros, & Martens, 2012) and meta-analytical support (Patall, Cooper, & Robinson, 2008).

In contrast, according to the Cognitive Load Theory (Sweller, 2016), additional information, which is not relevant for a learning goal, should be avoided in order not to overload a learners' working memory. As a result, additional instructions with choice options might inhibit the learning process. Moreover, a learning content might be restricted in its possibilities to separate choice options, or choice options might lead to a disproportionately high effort in designing additional examples or learning materials. In these cases, practitioners often dread to include choice options, thereby accepting a loss of learners' autonomy and motivation. This study aimed at examining the inclusion of choice options without changing properties of digital learning materials (feigned choice). For example, providing learners with options to choose between two sub-topics of a learning material, which are both included in a subsequent text, can be a possibility to include choice without changing the material's content. This feigned choice paradigm is important to experimentally separate choice effects from the change of instructional materials, which is given by a “real” choice. In media contexts, a feigned choice might be sufficient to evoke an increase in autonomy, motivation and learning performance without losing credibility. In addition, the learning relevance of choice options is still

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questionable, so that even learning-irrelevant choice options, like different genres of background music, might be helpful to enhance the learners' motivation. The feigned choice paradigm as well as boundary conditions of choice options were the focus of this study.

2. Motivation and task-based learning

The concept of motivation is described in the SDT, a macro theory of humans' agentic action to assimilate and integrate knowledge (Vansteenkiste, Niemiec, & Soenens, 2010). According to this theory, humans pursue basic psychological needs (i.e., *competence*, *autonomy* and *relatedness*) in the interaction with their environment. These needs are either supported or impeded by the environment (Deci & Ryan, 2000). The need for competence is described by the desire to effectively cope with one's environment and the following experience of a sense of competence. The need for relatedness is connected with a sense of feeling connected with others. Finally, the need for autonomy is fulfilled when humans perceive themselves as being the origin of their own actions (Deci & Ryan, 2000, 2012). Autonomous experiences are defined by a feeling of self-endorsement and congruence with the own values and interests (Vansteenkiste et al., 2010). These experiences are mainly fostered when individuals face choice and volition in their actions. When one, two or all psychological needs are met, people evaluate their behavior to be self-determined. This state is also called intrinsic motivation. In contrast, when no need is satisfied, people are in a state of amotivation (or at least in a state of external regulation) and evaluate their behavior to be nonself-determined (Ryan & Deci, 2000). For example, the inclusion of autonomy-enhancing features can lead to increase a perception of self-determination which results in an increased intrinsic motivation.

If people attribute their actions as being autonomous, their actions tend to maintain. Moreover, perceptions of autonomy are positively correlated with task engagement and perceived competence (Deci & Ryan, 2012). Since the feeling of relatedness is harder to achieve in online learning environments because of its inherent lack of a direct social interaction, while the feeling of competence is mainly affected by the results of the learning process, autonomy-enhancing features seem to be a promising approach to enhance learner's performance in task-specific motivation processes. This assumption is in line with the unified theory of task-specific motivation (UMTM; de Brabander & Martens, 2014), which distinguishes autonomy in two concepts: personal autonomy and perceived freedom. Whereby personal autonomy refers to the experience of feeling oneself as the origin of choosing and performing an action, perceived freedom is defined as the experiencing the freedom to make decisions. Providing options to choose, in this case, does not always lead to an increase in a personal autonomy, since freedom can also be experienced as a cognitive burden (de Brabander & Martens, 2014). These “cognitive costs” of choice options can be described with the Cognitive Load Theory (Sweller, 2016). According to this theory, learning materials provide two types of cognitive load. First, learners need to understand the learning material elements and their interactivity in order to form a coherent mental model, which can be integrated into long-term memory. This load is called Intrinsic Cognitive Load (ICL) and refers to learning-relevant processes. Second, learners also need to cope with learning-irrelevant processes (i.e., Extraneous Cognitive Load; ECL). These processes depend on the design of the learning material. Since learners possess a limited working memory capacity, which deals with both load types, ECL processes should be reduced to a minimum in order to save working memory capacity for learning-relevant processes. According to the CLT, included additional autonomy-enhancing features, like feigned choice options, merely lead to additional cognitive processes, which are not needed to achieve a learning goal (i.e. additional ECL processes). However, CLT does not yet include possible learning-enhancing effects of non-cognitive processes on learning.

3. Effects of choice on learning and cognitive load

People feel more autonomous when they are enabled to choose between options (Katz & Assor, 2007). The provision of choice increases the intrinsic motivation of students and their situational interest in the learning task (e.g., D'Mello, 2013; Høgheim & Reber, 2015; Høgheim & Reber, 2017; Reber, Hetland, Chen, Norman, & Kobbeltvedt, 2009; van Loon et al., 2012). This effect was also proven by a meta-analysis (Patall et al., 2008). Results show that choice is able to increase the intrinsic motivation, effort, perceived competence and task performance of learners, while subsequent learning scores were not significantly increased. There is also evidence that positive choice effects remain even for irrelevant choices or choice that appear trivial (e.g., Cordova & Lepper, 1996; Swann & Pittman, 1977). Patall (2013) stated that a provision of choice is additionally supposed to enhance learners' positive mood. A higher task value induced by choice is positively related with satisfaction and a motivation to continue with a task, whereby motivation is negatively correlated with negative emotions like boredom or frustration (Reynolds & Symons, 2001). This self-reward function of choice also found neurological evidence (Leotti & Delgado, 2011). It was also demonstrated that an increased situational interest elicited by the provision of choice promotes engagement in a learning task and leads to a higher invested mental effort (e.g., Flowerday, Schraw, & Stevens, 2004; Patall, 2013).

More recent research showed that choice can also have a restricted effect or even worsening influences. Some results show that choice is only supposed to increase positive feelings (e.g., Flowerday & Shell, 2015) and does not significantly influence learning in school (e.g., Evans & Boucher, 2015; Wijnia, Loyens, & Derous, 2011). In contrast, one case showed that a choice of learning topics was found to be a sufficient method in order to enhance learning performance (Reynolds & Symons, 2001). The researchers showed that a choice of books in a reading class can increase students' accuracy in reading and interest in the book. Other researchers additionally revealed that choice was able to enhance test scores of students in school situations (e.g., Patall, Cooper, & Wynn, 2010; Patall, Vasquez, Steingut, Trimble, & Pituch, 2017) or in motor learning tasks (e.g., Lewthwaite, Chiviacowsky, Drews, & Wulf, 2015; Post, Fairbrother, & Barros, 2011). This might be resulting from the increase of analytical thinking techniques when students were able to choose between options (Savani, Stephens, & Markus, 2017). Although there were several attempts to explain how choice effects on motivation can be explained, there are only few experiments trying to show correlational or mediational effects of autonomy or motivation on learning outcomes. In a study by Linnenbrink-Garcia, Patall, and Messersmith (2013) choice was found as a significant predictor for situational interest, whereby an increase of situational interest was found to be a mediator of increased perceived competence scores. Kusurkar, Ten Cate, Vos, Westers, and Croiset (2013) revealed that an increased autonomy can lead to an improved choice of study strategies, which then leads to an increased academic performance. In contrast, Flowerday and Shell (2015) presented results that suggest that choice is only able to increase a positive attitude, whereby this attitude is positively correlated with a knowledge test.

In fact, there is only little evidence for choice effects in the field of learning with digital learning materials. In a study by Ozogul, Johnson, Atkinson, and Reisslein (2013), one group of middle-school students were able to choose between different pedagogical agents in contrast to a group without a choice. The transfer score of the choice group was significantly greater. In contrast, their ratings of the program and their perceived difficulty were not significantly different from the no choice group. However, the researchers suggest to further examine choice in terms of autonomy ratings, motivation, cognitive perceptions and learning outcomes. In more detail, there is still a lack of studies examining the effects of choice on cognitive load. A study by Zimmerman and Shimoga (2014) in the research area of marketing has shown that cognitive load is directly connected with the task to choose between

options. In this study, choice options became more effective when cognitive load was high, whereby the overall cognitive load was reduced after the manipulation. Whether the inclusion of choice options can also reduce the cognitive load of learners, still needs to be examined.

4. Moderators of choice effects

The plurality of results in the field of choice research might stem from the multitude of moderators influencing its effectiveness. In the meta-analyses by Patall et al. (2008) several moderators of the effect of choice on intrinsic motivation were found. For example, too many choice moments or too many choice options can lead to detrimental effects (e.g., choice-overload effect, Iyengar & Lepper, 2000; too-much-choice effect, Scheibehenne, Greifeneder, & Todd, 2010). According to Patall et al. (2008), between two and five choice options should be chosen. Choice is also more efficient when students were not rewarded after a learning situation in contrast to any external rewards (Deci, Koestner, & Ryan, 1999). In addition, children were more amenable to choice effects than adults (Patall et al., 2008). Even the sex of people might interact with the effectiveness of choice, while females are more affected by choice than male learners (e.g., Oxford & Nyikos, 1989). Low-achieving students of a sample by Sweet, Guthrie, and Ng (1998) benefited less from choice options than high-achieving students.

Choice options can be relevant for a personal learning goal when the content of the learning material is changed (e.g., a choice between two topics). Choice options can also be irrelevant for a personal learning goal when learners recognize that a choice between these options is not important to reach a learning goal (e.g., a choice between two pieces of a background music). Patall et al. (2008) showed that a choice, which is instructionally irrelevant, was found to be more effective in enhancing motivation than a choice, which is instructionally relevant. The researchers explained their finding by suggesting that irrelevant choices might impact learners' positive affect more than relevant choices and thus, might increase the effects of choice.

In contrast to this assumption and according to Keller's ARCS-Model (Attention, Relevance, Confidence, and Satisfaction Model, 2010), a high relevance of instructional messages is beneficial for motivational processes. If learners cannot connect the instructional message with a personal or instructional learning goal (e.g., an irrelevant choice), their motivation is going to decrease further. In this case, learning-irrelevant choices might be less influential to increase a learner's autonomy than learning-relevant choices. This study also aimed at examining the moderating role of the relevance of choice options.

5. Research hypotheses

The present study aimed at gaining insights in the effects of choice in learning with digital media. In more detail, choice was supposed to increase a learner's perception of autonomy and intrinsic motivation and decrease his or her perception of external regulation (e.g., Deci & Ryan, 2012; Kusurkar et al., 2013). In order to be able to compare the effects of choice without losing a comparability between groups with or without a choice (because of a change in the instructional materials), a feigned choice paradigm was used.

H1. Learners with feigned choice options assess their autonomy and intrinsic motivation as higher and their external regulation as lower compared to learners without these choice options.

In addition, a provision of choice was found to increase the task performance of learners (e.g., the retention of information; Patall et al., 2008) and, in some cases, their subsequent learning performance (e.g., the understanding of a topic; Patall et al., 2017). This study tried to replicate these findings within the field of digital learning materials.

H2. Learners with feigned choice options achieve higher learning scores (retention, understanding) than learners without choice options.

Since choice is supposed to increase an additional non-relevant cognitive load according to the cognitive load theory (e.g., Sweller, 2016), perceptions of cognitive load should differ between groups with or without a choice.

H3. Learners with feigned choice options differ in their perception of cognitive load from learners without choice options.

There is a large body of possible moderators of the choice effect. Relevance, as a second key factor of motivation in SDT, however, can be seen as a fundamental moderator of choice effects. Although there is some meta-analytical evidence for differences in the learning relevance of choice options (Patall et al., 2008), an empirical support is still missing. In line with the meta-analytical results, the second experiment was additionally conducted to examine if the relevance of choice options (i.e., instructional relevance; differing from learning-irrelevant to learning-relevant) will affect learning scores.

H4. Feigned choice effects are influenced by the relevance of the choice options.

Finally, this study aimed at examining perceived autonomy and intrinsic motivation as factors mediating the effects of choice on learning. For this, a mediation analysis model (see Fig. 1) combined with a mediation hypothesis was created to be verified in this study.

H5. The effect of choice on learning (retention, transfer) is mediated by perceived autonomy and intrinsic motivation.

In this study, two experiments were conducted in order to substantiate the findings. Both experiments relied on the hypotheses mentioned above, while Experiment 2 additionally examined the moderating influence of the relevance of choice options on the effect of choice on learning. For an overview, all supposed effects are displayed in Fig. 2.

6. Experiment 1

In this study, autonomy is induced by a provision of one topic-choosing situation before the learning environment starts. The present study will examine if a feigned choice between two different topics of content will enhance learners' perception of autonomy, and in conclusion will enhance their learning outcomes in contrast to no choice option.

6.1. Method

6.1.1. Participants and design

Overall, 79 secondary school students (62% female; age: $M = 17.30$, $SD = 1.09$) participated in this study. All students attended a 3-year vocational upper secondary school in Greiz. Students were either 11th (52%) or 12th grade, and profiled in either economy (52%) or media design. The mean knowledge score based on the prior knowledge questionnaire, described in the knowledge tasks section,

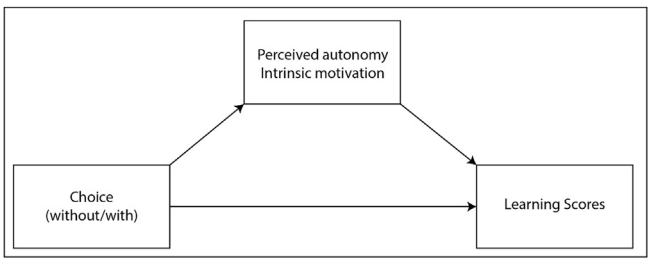

Fig. 1. Hypothesized mediation on the effect of choice on learning scores by perceived autonomy and intrinsic motivation.

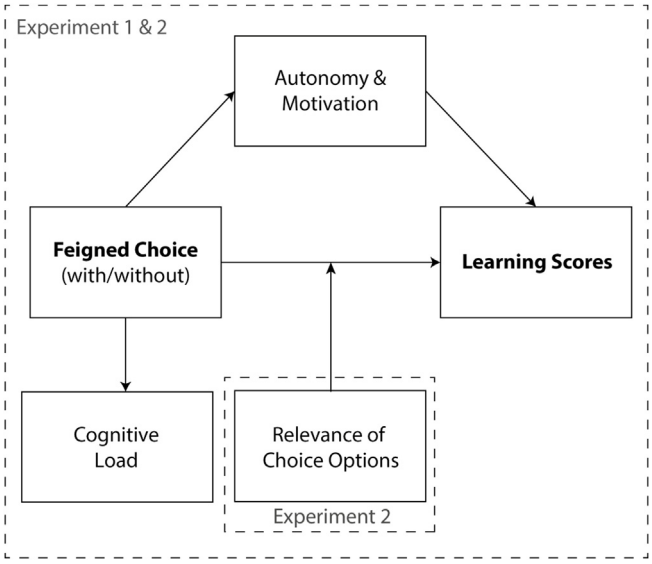

Fig. 2. Overview of the examined effects in Experiment 1 and 2.

was 0.63 points out of 3. This score can be seen as a rather low in prior knowledge. Moreover, no student had been taught in the learning topics before. In order to avoid possible differences between a choice group and a no choice group and in order to be able to more clearly analyze the effects of choice, choice options were feigned (for a more detailed description read the section *learning materials*). Since most of these studies showed medium to high transfer effect sizes, we conducted a power analysis with a one-factorial design (with two factor levels) and an effect size of $\eta_p^2 = .14$. Results showed a minimum sample size of 52 participants for $\alpha = .05$ and $(1\text{-}\beta) = 0.80$. In conclusion, we did not stop sampling procedure before this minimum sample size. Students were randomly assigned to either a control group without a choice (N = 38) or a treatment group with a feigned choice (N = 41) of the learning topic.

6.1.2. Learning materials

HTML webpages were used to design the learning materials. These webpages consisted of a starting page, a menu page and eight learning text pages (for an overview see Fig. 3). The webpages were identical across the experimental conditions, except for the starting page. For students in the group with choice, the starting page consisted of the instruction: "Choose between one of the following two learning texts in order to determine its focal point!," and two buttons labeled with either "social science" or "natural science". Students could choose between these two options. Within the no choice group, only one button labeled with *start* was displayed on the starting page. Although different buttons were shown on the starting pages, all buttons led to the same learning menu page with exactly the same content (feigned choice paradigm). This procedure was necessary in order to make the learning task comparable. In order to not confuse of frustrate students who had a choice on two different topics, while the learning text was designed to consist of both topics. In fact, on the basis of experimental protocols, no participant within the choice group complained about the content of the learning text or a previous choice. The menu page consisted of a heading introducing the learning topic "desertification" and five buttons. Four buttons were labeled with the titles of the four sections of the learning text: "Introduction", "Causes", "Consequences", and "Countermeasures". In addition to these buttons, a fifth button labeled with "I read all texts" was displayed on the menu page. This button led participants to the questionnaires after reading the learning text, while the button was not clickable until all subsections had been read. All pages of the learning materials additionally included a grey bar labeled with the remaining time for the learning materials (counting down from 15 min). The text pages covered all parts of the learning text, while two text pages were used for each section. Overall, the text consisted of 1159 words and was created with the help of different sources about desertification (e.g., Mainguet, 1994; Mensching, 1990). Some parts of the text consisted of biological and physical facts about desertification (e.g., the nutrient balance of useable areas) and some parts included social facts (e.g., the collaboration of local people and aid organizations) so that an equal amount of both aspects was ensured. After reading the text of one subtopic and using a "Next"-button, students were redirected to the menu page, where a green check mark was shown next to section heading which were already visited. In case that the pre-set time for the learning materials expired, students would have been directly directed to the next part of the experiment. A look into the click protocols revealed that no student took longer than the maximum amount of time.

6.1.3. Knowledge tasks

Prior knowledge ($\alpha = .69$) was measured with three open-answer tasks: (1) "Explain what desertification is!", (2) "Name examples for causes of desertification!", and (3) "Name examples for impacts of desertification!" On the basis of a pre-set schema of correct answers, each answer was checked by two independent raters and each correct answer was rewarded with one point (maximum prior knowledge score: three points). Interrater-reliability can be seen as good; ICC (2, k) = [.933, .964], F (1, 78) = [14.45, 27.49], $p < .001$. Although for some questions more than one correct answer was possible, only one answer was needed to reach one point (a maximum of three points for all questions).

Retention ($\alpha = .80$) and *transfer* ($\alpha = .73$) learning tasks were developed to gain insights in the learning performance of the participants. According to Mayer (2014), retention is defined as remembering. Remembering refers to being able to recognize or reproduce the learning content. In contrast, transfer problems are defined as understanding (Mayer, 2014). Retention performance was measured by eight single choice questions with four possible answers each, for example; "Where can one find the biggest desertification zone of the past 100 years?" In addition, one cloze text with four gaps within sentences like "Shorter times of fallowing and a false … leads to a shortage of nutrients in soils" was displayed. Students need to fill in the correct word named in the learning text to fulfil this task. Finally, one open format task ("Explain what the 'bottom up' principle means!") was included. Inter-rater reliability can be seen as good, ICC (2, k) = .956, F (78, 78) = 22.61, $p < .001$. If correct, single choice questions and the cloze text were rewarded with four points. The open format question was rewarded with two points, because only one answer needs to be given in contrast to all other retention task formats. For this, a maximum of 38 points could be reached within this scale.

In contrast, transfer knowledge is defined as "understanding." Learners need a coherent mental model to help them solve novel problems not explicitly presented in the instructional material (Mayer, 2014). Transfer was measured by ten multiple choice questions with four pre-set answers. Students were instructed that either one, two, three or all four pre-set answers can be correct. For example, the question "Which of the following terms also refers to desertification?" was displayed together with the answers "Progressive dehydration of farmland", "Agroforestry", "Sahel syndrome", and "Brazilian problem". Each correct check mark and each correct omission of a check mark was rewarded with one point. In conclusion, students could reach a maximum of four points for each question and a maximum of 40 points for the transfer performance scale.

6.1.4. Additional measures

In order to measure if students' cognitive processes were influenced by the experimental conditions, a cognitive load measure was used (Eysink et al., 2009). The items reflect both aspects of the cognitive load – namely *intrinsic cognitive load* (ICL; one item: "How easy or difficult

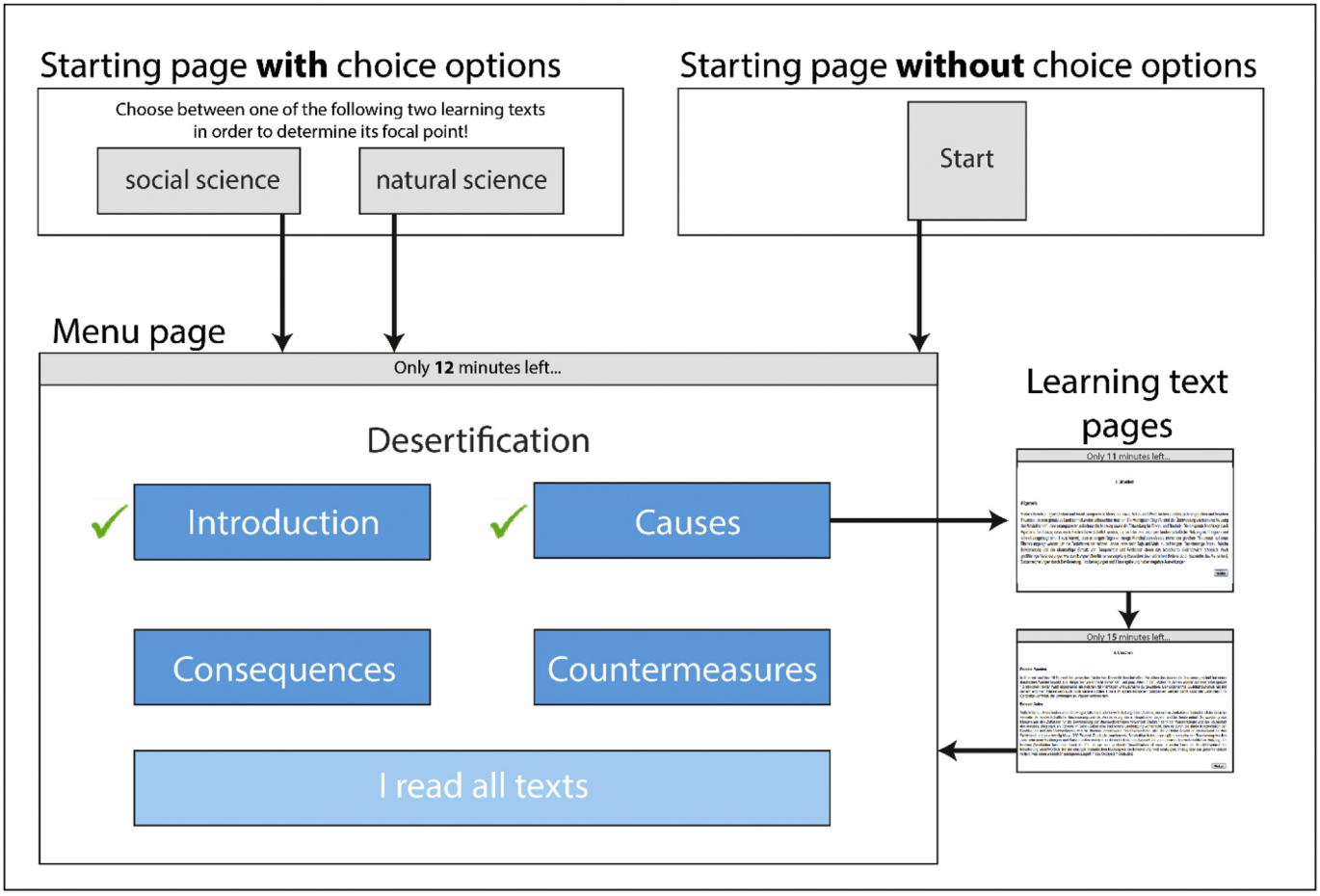

Fig. 3. Overview of the web-based learning environment on desertification. Starting page (with choice options vs. without choice options) differed according to the experimental condition.

was the material on desertification?") and *extraneous cognitive load* (ECL; three items; e.g., "How easy or difficult was it for you to work with the environment?"; $\alpha = .79$). Each item was rated on a 7-point scale ranging from "very easy" to "very difficult". Since choice is supposed to influence ratings of motivation, two questionnaires measuring *intrinsic motivation* ($\alpha = .84$) and *external regulation* ($\alpha = .87$) were included. The concepts partially reflect the dimensions intrinsic motivation and extrinsic motivation. The two 4-items' scales were retrieved from the Situational Motivation Scale (SIMS; Guay, Vallerand, & Blanchard, 2000). Participants had to rate pre-set answers like "because I am supposed to do it" according to the questions: "Why were you engaged with the previous activity?" on a 7-point scale ranging from "corresponds not at all" to "corresponds exactly".

In addition, one item was included to ensure that the manipulation of choice led to a change in the feeling of autonomy. For this, the autonomy-measuring item of Eisenberger, Rhoades, and Cameron (1999), "How much choice did you have as to whether or not to carry out the picture task", was adapted to this experiment. The wording of the *perceived autonomy* item is "How low or high do you estimate your own autonomy during the learning web pages?" This item was displayed with a 7-point scale with "1 – very low" and "7 – very high" at the beginning and the end of the scale. Moreover, the demographic information of age, sex, subject of study, and class level was collected.

6.1.5. Procedure

The experiment consisted of three parts, which were shortly explained by the experimenters at the beginning. A first questionnaire gathering data on prior knowledge, the learning webpages, and a second questionnaire to measure all other variables. The order of measure the second questionnaire was set to (1) intrinsic motivation and external regulation, (2) cognitive load facts, (3) retentions and transfer tasks, (4) demographic data, and (5) perceived autonomy. All parts of the experiment were created as webpage versions so that they could be connected via hyperlinks. In addition, a computer lab at the participating school was prepared with a random order of experimental software conditions on all computers. The experimenter introduced all tasks and parts of the experiment with a pre-made instructions form in order to increase objectivity. After these instructions, students started with their experiments. Students took between twelve and 14 min to read all texts and between 40 and 50 min to complete all three parts. Time on task was logged to analyze possible differences. In order to keep an experimental atmosphere, students were instructed to stay at their workplaces until everyone was ready. After all participants finished their task, they were rewarded with a small present. School breaks were used to prepare the next experiment. All experimental runs were conducted within one school day from the first to the fourth lesson. Group sizes of each experiment differed between 18 and 21 students.

6.2. Results and discussion

In the analysis of data, multivariate analyses of covariance (MANCOVAs) and univariate analyses of covariance (ANCOVAs) were conducted in order to assess differences between groups. For all analyses of differences, the group variable *choice* (with vs. without) was used as independent variable. Since there were no significant differences between the experimental groups in terms of age, gender, subject of study, class level, prior knowledge, and time on task ($ps > .05$), only

Table 1
Mean scores and standard deviations of all variables used in the analyses of Experiment 1.

Groups	N	Perceived Autonomy		Learning: Retention		Learning: Transfer		Intrinsic Motivation		External Regulation		Intrinsic Cognitive Load		Extraneous Cognitive Load	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Without a choice	38	3.76	0.93	7.45	2.13	27.18	3.66	3.16	0.99	5.14*	1.15	4.74*	1.03	3.44	0.89
With a choice	41	5.25*	0.95	8.68*	2.36	29.34*	3.23	3.88*	0.97	4.37	1.78	3.63	1.09	3.56	1.08

Mean scores with an asterisk are significantly ($p < .05$) higher than their comparative scores.

prior knowledge as an important moderator of multimedia learning (Chen, Kalyuga, & Sweller, 2017) was used as a covariate for the analyses. However, only significant influences of this covariate were reported. Pre-defined test assumptions were only reported if significant violations occur. Descriptive results of all dependent measures according to the experimental groups were displayed in Table 1. Effect sizes were only computed if significant effects occurred.

6.2.1. Perceived autonomy

An ANCOVA was conducted with perceived autonomy as dependent measure. Results show a significant difference between both experimental conditions, F (1, 76) = 27.85, $p < .001$, $\eta_p^2 = .27$. A closer look within the manipulation of choice shows that students with a choice ($M = 4.56$, $SD = 1.14$) show higher scores than students with no choice ($M = 3.26$, $SD = 1.03$). According to the high effect size (Cohen, 1988), manipulation can be seen confirmed and further analyses are accepted.

6.2.2. Learning results

In order to analyze differences between the experimental groups in terms of the learning tasks, a MANCOVA was conducted with retention and transfer scores as dependent measures. A significant main effects was found for choice, (Wilk's $\Lambda = 0.88$), F (2, 75) = 4.93, $p = .010$, $\eta_p^2 = .12$. This test was divided into two follow-up ANCOVAs for retention and transfer as dependent variables. Retention results show that students receiving a choice scored significantly higher than students with no choice, F (1, 76) = 5.88, $p = .018$, $\eta_p^2 = .07$. This difference represents a medium to large effect size. The same direction can be seen within transfer performance. Again, students with a choice scored significantly higher than students without a choice, F (1, 76) = 7.65, $p = .007$, $\eta_p^2 = .09$, representing a medium to large effect size.

6.2.3. Motivational states

In order to analyze differences in motivation among the experimental conditions, a MANCOVA was conducted with intrinsic motivation and external regulation as dependent measures. A significant main effect was found for choice, (Wilk's $\Lambda = 0.65$), F (2, 75) = 6.84, $p = .001$, $\eta_p^2 = .15$. This test was divided into two follow-up ANCOVAs. Based on the data of intrinsic motivation, the variance analysis revealed significant differences showing that students receiving no choice reported a significantly lower intrinsic motivation than students with a choice, F (1, 76) = 10.79, $p = .002$, $\eta_p^2 = .12$. This difference represents a medium to large effect size. The analysis of external regulation also revealed significant differences, F (1, 76) = 5.07, $p = .027$, $\eta_p^2 = .06$, with lower scores for students with a choice.

6.2.4. Cognitive processes

Another MANCOVA was conducted with ICL and ECL as dependent measures. A significant main effect was found for choice, (Wilk's $\Lambda = 0.75$), F (3, 74) = 8.23, $p < .001$, $\eta_p^2 = .25$. This test was divided into two follow-up ANCOVAs for ICL and ECL as dependent variables. Only the ICL analysis revealed significant differences showing that students receiving no choice reported a significantly higher ICL than students with a choice, F (1, 76) = 22.77, $p < .001$, $\eta_p^2 = .23$. This difference represents a large effect size. No significant difference were found for ECL, F (1, 76) = 0.29, $p = .590$.

6.2.5. Mediation analysis

After demonstrating the effects of choice on learning performance as well as cognitive and motivational measures, the effects of all presupposed mediators (perceived autonomy and intrinsic motivation) were analyzed. In order to check the collinearity of all constructs (Hayes, 2009), correlations among all dependent, independent and covariate variables were calculated (see Table 2). Since all mediators need to significantly correlate with either retention or transfer, only perceived autonomy was included in the mediation analysis of choice on retention and transfer. No outliers were detected for the dependent variables.

For this, a series of regression analyses on the basis of the *PROCESS* macro (Hayes, 2013) were run to explore the role of perceived autonomy in mediating the effect of choice on retention (see Fig. 4). This analysis shows that choice had a direct effect on retention (*c*; β = 1.23, $t = 2.44$, $p = .017$) and a direct effect on perceived autonomy (*a*; β = 1.30, $t = 5.29$, $p < .001$). The effect of perceived autonomy on retention (*b*) was also significant (β = 0.79, $t = 3.58$, $p < .001$). Last, the direct effect of choice on retention, controlling for perceived autonomy is not significant (*c'*, β = 0.21, $t = 0.39$, $p = .696$), suggesting a mediation by perceived autonomy. The indirect effect was calculated by using a bootstrapping procedure with $k = 5000$ trials, since this test should be preferred in contrast to the Sobel test (Hayes, 2009). As a result, the indirect effect, ab/c = .825, $SE = 18.13$, can be seen as significantly different from zero 95% CI [.311, 2.865]. Overall, the mediation explains around 83% of the total effect.

The same series was run for transfer as independent variable. This analysis shows that choice had a direct effect on transfer (*c*; β = 2.16, $t = 2.78$, $p = .007$) and a direct effect on perceived autonomy (*a*; β = 1.29, $t = 5.29$, $p < .001$). In contrast, the effect of perceived

Table 2
Correlations between all independent variables (IV) and dependent variables of the Experiment 1.

Variables	1	2	3	4	5	6	7	8
1. Choice (IV)	–							
2. Perceived autonomy	.516***	–						
3. Intrinsic motivation	.349**	.263*	–					
4. External regulation	-,250*	-.080	-.228*	–				
5. Retention	.268*	.452***	-.015	-.130	–			
6. Transfer	.302**	.278*	.146	-.058	.409***	–		
7. Intrinsic cognitive load	-.465***	-.954***	-.220	.170	-.339**	-.213	–	
8. Extraneous cognitive load	.062	-.080	-.213	.012	-.153	.042	.113	–

*$p < .05$. **$p < .01$. ***$p < .001$.

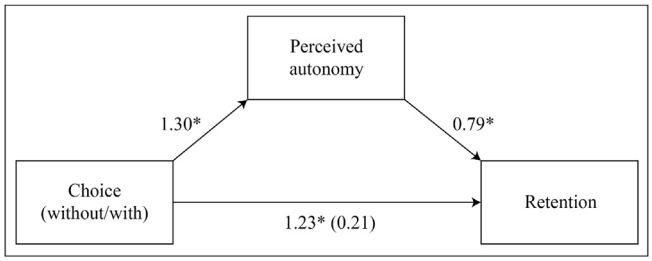

Fig. 4. Beta coefficients of the mediation analysis paths for the mediating effect of perceived autonomy on the relation between choice and retention in Experiment 1.
Note. *$p < .05$.

autonomy on transfer (*b*) was not significant ($\beta = 0.47$, $t = 1.32$, $p = .091$), suggesting that the effect on transfer is not mediated by perceived autonomy.

6.2.6. Discussion

Experiment 1 aimed at revealing if choice effects can be found with a feigned choice paradigm. Both retention and transfer scores were raised by the implementation of two choice options, although these options did not change the content a learner received. Moreover, a provision of choice was able to increase the students' perceived autonomy and intrinsic motivation, while the extrinsic regulation was lowered. These results are in line with previous research findings (Patall, 2013). On the cognitive side, students reported a smaller amount of intrinsic cognitive load – mainly interpreted as a function of task complexity (Korbach, Brünken, & Park, 2017). Interestingly, the increased score of intrinsic motivation was not found as a mediator of the increased learning scores. It seems that intrinsic motivation needs to be handled like an independent outcome of choice rather than a process variable. In contrast, perceived autonomy was found as a mediator of the effect of choice on retention. Since choosing between topic options might affect motivational processes closely to the learning text (i.e., a thorough reading of the text) rather than a motivation to imagine possible problem situations for the acquired knowledge, this results might be obvious. However, the results have to be interpreted with caution for several reasons: (1) the perceived autonomy item was self-made and one-item solution might suffer from a low reliability, (2) the results rely on only one experiment with a limited generalizability for all learning topics, (3) the operationalization of choice is only feasible for learning topics with at least two separable learning areas, and (4) students in both conditions were able to choose their learning paths because of a menu structure of the learning web pages. For this, a second experiment was conducted to counteract these limitations.

7. Experiment 2

7.1. Method

7.1.1. Participants and design

Overall, 87 secondary school students (45% female; age: $M = 14.22$, $SD = 1.01$) participated in this study. All students attended a 3-year vocational upper secondary school in Greiz. Students were either in grade 8 (44%), grade 9 (16%), or grade 10 (40%). The mean prior knowledge score (described in the knowledge tasks section) was 0.29 points (maximum: 3 points). This score can be seen as a rather low in prior knowledge. Moreover, no student had been taught in the learning topics before. Students were block-randomly assigned (i.e., controlling for equal group sizes) to one group of a 2×2 factorial, between-subject design with the factors presence of a learning-relevant choice (with vs. without) and presence of a learning-irrelevant choice (with vs. without). Since the learning effect sizes of Experiment 1 were relatively high, we conducted a power analysis with a two factor design (each with two factor levels) and an effect size of $\eta_p^2 = .12$. Results showed a minimum sample size of 60 participants for $\alpha = .05$ and $(1-\beta) = 0.80$. Twenty-one student received a learning-relevant and a learning-irrelevant choice, 24 students participated in the group with only a learning-relevant choice, 21 students took part in the group with only a learning-irrelevant choice, and 21 students did not receive any choice.

7.1.2. Learning materials

HTML webpages were used to design the learning materials. These webpages consisted of two starting pages and eight learning text pages. The learning text consisted of information on how string and wind instruments function. The webpages were identical across the experimental conditions, except for the starting pages. Again, a feigned choice paradigm was used for both choice factors.

For students in the group with a learning-relevant choice, the fist starting page consisted of the instruction: “The following learning text deals with the world of tones in general. Choose between one of the following two learning texts in order to determine its focal point!,” and two buttons labeled with either “The physics of sound waves” or “The formation of music”. Students could choose between these two options. For students without a learning-relevant, only the text “The following learning text deals with the world of tones in general,” and one button labeled with “Proceed” was displayed on the first starting page.

For students in the group with a learning-irrelevant choice, the second starting page consisted of the instruction: “In addition, you will listen to a piece of music. You can choose between two alternatives!,” and two buttons labeled with either “Classical orchestral work” or “Modern instrumental piece”. Students could choose between these two options. For students without a learning-irrelevant, only the text “In addition, you will listen to a piece of music. Please click ‘Proceed’ to begin!,” and one button labeled with “Proceed” was displayed. Although different buttons were shown on the starting pages, all buttons led to the same learning webpages. Students in all conditions listened to the same piece of background music – namely a modern interpretation of Antonio Vivaldi's “The four seasons” by Max Richter (2014). In addition, all students read the same learning text. This piece of music combines classical and modern aspects of music. Again, on the basis of experimental protocols, no participant within the learning-relevant or learning-irrelevant choice groups complained about the content of the learning text, piece of music he or she listened to or his or her choice possibilities.

The text webpages covered all parts of the learning text, while some text webpages included illustrations of how music instruments work (for an overview see Fig. 5). Overall, the text consisted of 890 words as well as four instructional pictures and was created with the help of a scientific web resource (Martin, 2017). All pages of the learning materials additionally included a grey bar labeled with the remaining time for the learning materials (counting down from 15 min). Students could use a “Next”-button, in order to reach the next learning webpage. The last webpage contained the instruction “By clicking on ‘Exit the learning webpages’, you will proceed with the next questionnaire,” and a button labeled with “Exit the learning webpages”. In case that the preset time for the learning materials expired, students would have been directly directed to the next part of the experiment. A look into the click protocols revealed that no students took longer than the maximum amount of time.

7.2. Knowledge tasks

7.2.1. Prior-knowledge measurement

Prior knowledge ($\alpha = .82$) was measured with two open-answer tasks: (1) “Please explain how wind instruments functions!”, and (2) “Please explain how a resonance body functions!” On the basis of a preset schema of correct answers, each answer was checked by two independent raters and each correct explanation was rewarded with one

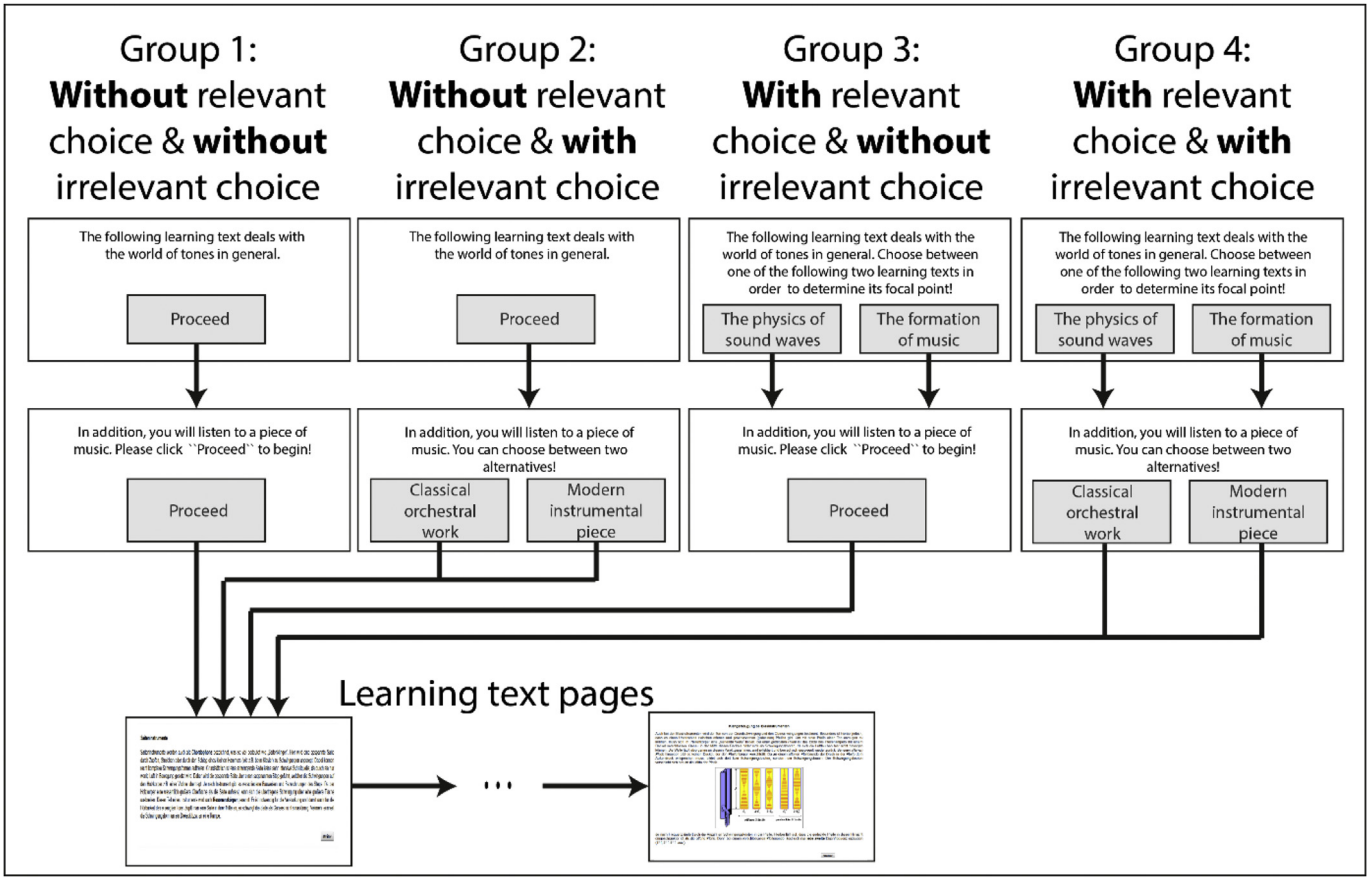

Fig. 5. Overview of the manipulation of choice and the web-based learning environment on how string and wind instruments function. Starting pages differed according to the experimental group.

point (maximum prior knowledge score: two points). Interrater-reliability can be seen as good; ICC (2, k) = [.917, .978], F (1, 86) = [12.03, 45.14], $p < .001$.

Retention (α = .72) and *transfer* (α = .68) learning tasks were developed to gain insights in the learning performance of the participants. Retention performance was measured by seven multiple choice questions with three possible answers each. Students were instructed that either one, two, or all three pre-set answers can be correct. For example, the question "What are longitudinal waves?" was displayed together with the answers: (1) "Acoustic waves, which swing contrary to their spreading direction", (2) "Acoustic waves, which swing in line with their spreading direction", and (3) "Acoustic waves, which swing perpendicularly to their spreading direction." If all answers of a question are correctly marked (or not marked in the case of a wrong answer), a question was rewarded with three points. For this, a maximum of 21 points could be reached within this scale.

Transfer performance was also measured by seven multiple choice questions with three pre-set answers. For this scale, pre-set pictures or examples had to be evaluated by the students. For example, a picture of a reed pipe with a shallot was displayed together with the question "What kind of pipe do you see on the picture?" Students additionally received the answers (1) "A reed pipe with a reed stop", (2) "A reed pipe with a shallot", and (3) "A flue pipe". Each correct check mark and each correct omission of a check mark was rewarded with one point. This makes a maximum of three points for each question and a maximum of 21 points for this scale.

7.2.2. Additional measures

The same motivational scales measuring intrinsic motivation and external regulation as in Experiment 1 were used for this experiment. ICL (α = .89) and ECL (α = .89) were measured by the two eponymous scales from Leppink, Paas, van Gog, van der Vleuten and van Merriënboer (2014), because of a higher reliability (Experiment 1; ICL: only one item; ECL: α = .79). Example items were "The topics covered in the learning material were very complex" (ICL) or "The instructions and explanations within the learning material were very unclear" (ECL). These items were adapted to the text-based environment as in Schneider, Nebel, Beege, and Rey (2018). The items had to be rated on an 11-point scale ranging from "I totally disagree" to "I totally agree." In addition, the self-prepared item to measure perceived autonomy was replaced by a questionnaire from Houlfort, Koestner, Joussemet, Nantel-Vivier, and Lekes (2002), covering the scales of *affective autonomy* (α = .72; e.g., "I felt pressure") and *decisional autonomy* (α = .91, e.g., "I believe I had a choice over strategies to try"). Students had to rate these items on a 7-point scale ranging from "I totally disagree" to "I totally agree."

7.2.3. Procedure

The procedure of Experiment 2 was almost identical to the procedure of Experiment 1 except for small differences: (1) The motivation questionnaire with the scales of intrinsic motivation and external regulation were used directly before the students started reading the learning webpages and directly after the learning webpages in order to be able to calculate differences scores, (2) Students in a group with a learning-irrelevant choice received this choice directly after the learning-relevant choice, and (3) affective and decisional choice was measured instead of the perceived choice item of Experiment 1. Students took between ten and 14 min to read all texts and between 40 and 45 min to complete all parts of the experiment (i.e., a first questionnaire, the learning webpages, and a second questionnaire). All

Table 3
Mean scores and standard deviations of all groups of Experiment 2.

Type of Choice			Affective autonomy		Decisional Autonomy		Learning: Retention		Learning: Transfer		Δ Intrinsic Motivation		Δ External Regulation		Intrinsic Cognitive Load		Extraneous Cognitive Load	
Relevant	Irrelevant	*N*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
+	+	21	5.50	1.11	5.10	0.84	16.48	2.52	11.43	2.62	1.08	1.64	0.02	1.03	5.20	1.75	4.48	1.44
+	–	24	5.11	1.08	4.29	0.69	14.38	2.32	11.46	2.55	0.02	0.94	−0.14	0.95	4.99	1.61	4.86	1.29
–	+	21	5.12	0.82	4.10	0.71	14.24	3.37	10.52	2.46	−0.21	0.90	0.45	2.03	6.19	1.83	4.32	1.76
–	–	21	4.97	1.06	3.37	0.98	13.43	2.64	10.19	2.89	−0.61	0.98	0.93	1.62	6.17	2.23	4.92	1.80

+ with. − without. Δ means difference scores (scores after learning – baseline scores).

experimental runs were conducted within one school day from the first to the sixth lesson. Class sizes of each experimental run differed between eleven and 20 students.

7.3. Results and discussion

The same types of analyses as in Experiment 1 were used for all analyses of differences, whereby the group variables *learning-relevant choice* (RC; with vs. without) and *learning-irrelevant choice* (IC; with vs. without) were used as independent variables. Since there were no main effects or interactions among the variables age, gender, grade, preference for instrumental or classical music, expertise in music, time on task, and time of experiment (*ps* > .05), only prior knowledge was used as a covariate. However, only significant influences of this covariate were reported. Pre-defined test assumptions were only reported if significant violations occur. Descriptive results of all dependent measures according to the experimental groups were displayed in Table 3. Effect sizes were only computed if significant effects occurred. Confidence intervals for effect sizes were calculated based on the procedure described by Fritz, Morris, and Richler (2012).

7.3.1. Perceived autonomy

A MANCOVA was conducted with perceived affective autonomy and perceived decisional autonomy as dependent measures. The analysis revealed a significant main effect for RC; (Wilk's $\Lambda = 0.72$), F (2, 81) = 15.42, $p < .001$, $\eta_p^2 = .28$, and a significant main effect for IC; (Wilk's $\Lambda = 0.81$), F (2, 81) = 9.38, $p < .001$, $\eta_p^2 = .19$, whereby the interaction did not reach significance; (Wilk's $\Lambda = 0.99$), F (2, 81) = 0.15, $p = .860$, $\eta_p^2 < .01$. Regarding RC, a follow-up ANCOVA for perceived decisional autonomy revealed a significant difference, F (1, 82) = 9.09, $p = .003$, $\eta_p^2 = .10$, with higher scores for the group with a learning-relevant choice. There was no significant difference for perceived affective autonomy, F (1, 82) = 1.33, $p = .253$, $\eta_p^2 = .02$. Regarding IC, a follow-up ANCOVA for scores for perceived decisional autonomy also significantly differed, F (1, 82) = 8.03, $p = .006$, $\eta_p^2 = .09$, with higher scores for the group with a learning-irrelevant choice. Again, there was no significant difference for perceived affective autonomy, F (1, 82) = 1.53, $p = .220$, $\eta_p^2 = .02$.

7.3.2. Learning results

In order to analyze differences between the experimental groups in terms of the learning tasks, a MANCOVA was conducted with retention and transfer scores as dependent measures. The analysis revealed a significant main effect for RC; (Wilk's $\Lambda = 0.88$), F (2, 81) = 5.34, $p = .007$, $\eta_p^2 = .22$, and a marginal significant main effect for IC; (Wilk's $\Lambda = 0.93$), F (2, 81) = 2.98, $p = .057$, $\eta_p^2 = .07$, whereby the interaction did not reach significance; (Wilk's $\Lambda = 0.98$), F (2, 81) = 0.71, $p = .495$, $\eta_p^2 = .02$. This test was divided into follow-up ANCOVAs for retention and transfer as dependent variables. Retention results show that students receiving a learning-relevant choice scored significantly higher than students with no choice, F (1, 82) = 7.66, $p = .007$, $\eta_p^2 = .09$, 95%-CI [.008; .213]. Moreover, students with a learning-irrelevant choice also achieved higher retention scores than students without this choice, F (1, 82) = 6.02, $p = .016$, $\eta_p^2 = .07$, 95%-CI [.001; .169]. The effect sizes of both main effects did not significantly differ. The same analyses were conducted for transfer performance. Again, students with a learning-relevant choice scored significantly higher than students without a choice, F (1, 82) = 4.49, $p = .037$, $\eta_p^2 = .05$. In contrast, there was no significant difference for the condition of learning-irrelevant choice, F (1, 82) = 0.05, $p = .828$.

7.3.3. Motivational states

In order to analyze differences between the experimental groups in terms of motivation, a MANCOVA was conducted with intrinsic motivation and external regulation as dependent measures. The analysis revealed a significant main effect for RC; (Wilk's $\Lambda = 0.82$), F (2, 81) = 8.95, $p < .001$, $\eta_p^2 = .18$, and a significant main effect for IC; (Wilk's $\Lambda = 0.90$), F (2, 81) = 4.36, $p = .016$, $\eta_p^2 = .10$, whereby the interaction did not reach significance; (Wilk's $\Lambda = 0.96$), F (2, 81) = 1.76, $p = .178$, $\eta_p^2 = .04$. This test was divided into follow-up ANCOVAs for intrinsic motivation and external regulation as dependent variables. Results show that students receiving a learning-relevant choice perceived their intrinsic motivation as significantly higher than students with no choice, F (1, 82) = 14.25, $p < .001$, $\eta_p^2 = .15$, 95%-CI [.022; .256]. Moreover, students with a learning-irrelevant choice also reached higher scores for intrinsic motivation than students without this choice, F (1, 82) = 8.82, $p = .004$, $\eta_p^2 = .10$, 95%-CI [.012; .232]. The effect sizes of both main effects did not significantly differ. Looking at the scores of external regulation, students with a learning-relevant choice reached significantly lower scores than students without a choice, F (1, 82) = 5.96, $p = .017$, $\eta_p^2 = .07$. The difference for groups of learning-irrelevant choice did not significantly differ, F (1, 82) = 0.23, $p = .633$.

7.3.4. Cognitive processes

In order to analyze differences between the experimental groups in terms of cognitive processes, a MANCOVA was conducted with ICL and ECL as dependent measures. The analysis revealed a significant main effect for RC; (Wilk's $\Lambda = 0.87$), F (3, 80) = 3.95, $p = .011$, $\eta_p^2 = .18$, and a marginal significant main effect for IC; (Wilk's $\Lambda = 0.91$), F (3, 80) = 2.50, $p = .066$, $\eta_p^2 = .09$, whereby the interaction did not reach significance; (Wilk's $\Lambda = 0.99$), F (3, 80) = 0.08, $p = .967$, $\eta_p^2 < .01$. This test was divided into follow-up ANCOVAs for ICL and ECL as dependent variables. Results show that students receiving a learning-relevant choice perceived their ICL as significantly lower than students with no choice, F (1, 82) = 14.25, $p < .001$, $\eta_p^2 = .15$ [.025; .261]. Moreover, students with a learning-irrelevant choice also reached lower scores for ICL than students without this choice, F (1, 82) = 8.82, $p = .004$, $\eta_p^2 = .10$ [.010; .229]. The ECL did not differ for learning-relevant choice, F (1, 82) = 0.01, $p = .978$, or learning-irrelevant choice, F (1, 82) = 2.02, $p = .159$.

7.3.5. Mediation analysis

The same mediation analysis as in Experiment 1 was conducted. In

Table 4
Correlations between the independent variables (IV) and all dependent variables of Experiment 2.

Variables	1	2	3	4	5	6	7	8	9	10
1. Relevant choice (IV)	–									
2. Irrelevant choice (IV)	-.033	–								
3. Affective autonomy	.120	.132	–							
4. Decisional autonomy	.469***	.368***	.291**	–						
5. Intrinsic motivation	.362**	.276*	.446***	.367***	–					
6. External regulation	-.253*	-.041	-.301**	-.099	-.265*	–				
7. Retention	.264*	.247*	.118	.318**	.129	-.134	–			
8. Transfer	.206	.021	.017	.196	.055	-.111	.184	–		
9. Intrinsic cognitive load	-.300**	.027	-.263*	-.225*	-.265*	.286**	-.023	-.037	–	
10. Extraneous cognitive load	.020	-.158	-.263*	-.088	-.121	.321**	-.108	-.069	.408**	–

*$p < .05$. **$p < .01$. ***$p < .001$.

order to check the collinearity of all constructs, correlations among all dependent, independent and covariate variables were calculated (see Table 4). Both a learning-relevant choice and a learning-irrelevant choice only significantly correlated with retention as dependent variable. Since all mediators need to significantly correlate with either retention or transfer, only decisional autonomy was included in the mediation analysis of choice on retention. Again, no outliers were detected for the dependent variables.

For this, a first series of regression analyses were run to explore the role of perceived autonomy in mediating the effect of learning-relevant choice on retention (see Fig. 6). This analysis shows that learning-relevant choice had a direct effect on retention (c; $\beta = 1.52$, $t = 2.52$, $p = .014$) and a direct effect on perceived autonomy (a; $\beta = 0.34$, $t = 4.89$, $p < .001$). The effect of perceived autonomy on retention (b) was also significant ($\beta = 0.72$, $t = 2.15$, $p = .034$). Last, the direct effect of learning-relevant choice on retention, controlling for perceived autonomy is not significant (c', $\beta = 0.85$, $t = 1.26$, $p = .210$), suggesting a mediation by perceived autonomy. The indirect effect was calculated by using a bootstrapping procedure with $k = 5000$ trials. As a result, the indirect effect, (ab/c) = .44, $SE = 3.80$, can be seen as significantly different from zero 95% CI [.026, 2.084]. Overall, the mediation explains around 44% of the total effect.

A second series of regression analyses were run to explore the role of perceived autonomy in mediating the effect of learning-irrelevant choice on retention (see Fig. 7). This analysis shows that learning-irrelevant choice had a direct effect on retention (c; $\beta = 1.42$, $t = 2.35$, $p = .021$) and a direct effect on perceived autonomy (a; $\beta = 0.73$, $t = 3.65$, $p < .001$). The effect of perceived autonomy on retention (b) was also significant ($\beta = 0.76$, $t = 2.39$, $p = .019$). Last, the direct effect of learning-irrelevant choice on retention, controlling for perceived autonomy is not significant (c', $\beta = 0.86$, $t = 1.36$, $p = .177$), suggesting a mediation by perceived autonomy. The indirect effect was calculated by using a bootstrapping procedure with $k = 5000$ trials. As a result, the indirect effect, (ab/c) = .393, $SE = 2.33$, can be seen as significantly different from zero 95% CI [.080, 2.056]. Overall, the mediation explains around 39% of the total effect.

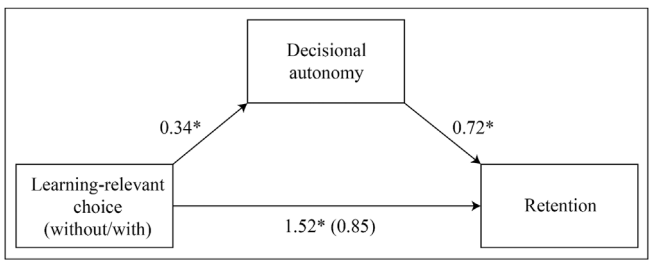

Fig. 6. Beta coefficients of the mediation analysis paths for the mediating effect of decisional autonomy on the relation between learning-relevant choice and retention in Experiment 2.
Note. *$p < .05$.

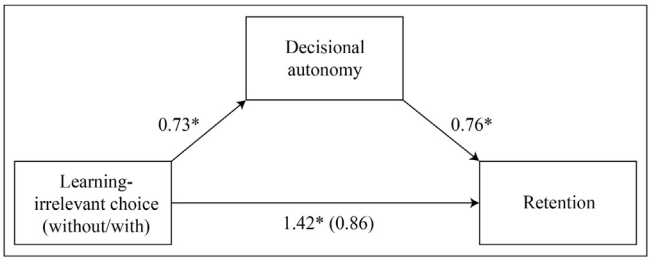

Fig. 7. Beta coefficients of the mediation analysis paths for the mediating effect of decisional autonomy on the relation between learning-irrelevant choice and retention in Experiment 2.
Note. *$p < .05$.

7.3.6. Discussion

The second experiment aimed at replicating findings from Experiment 1 and examining the learning relevance of choice options as moderator of the effect of choice on learning. In line with Experiment 1, a provision of a learning-relevant choice was found to increase students' retention and transfer scores as well as their perception of intrinsic motivation, while the scores of external regulation and intrinsic cognitive load decreased. In the examination of two different scores of autonomy, only decisional autonomy was significantly raised. In comparison with Experiment 1, decisional autonomy, as a type of perceived autonomy, was also found to be a mediator of the effect of learning-relevant choice on retention.

In addition to Experiment 1, a learning-irrelevant choice in form of a decision on the background music was examined. This type of choice was also found to enhance students' retention performance as well as their perception of intrinsic motivation. The intrinsic cognitive load was also significantly lowered. In contrast to the learning-relevant choice, a provision of a learning-irrelevant choice did not significantly increase students' transfer performance as well as the perception of external regulation. However, the effect of learning-irrelevant choice on retention was again mediated by decisional autonomy. This contrast of result between relevant and irrelevant choices might be explained by their varying nature of effect. While learning-relevant choices affect a learners' situational and personal interest (Patall, 2013), instructionally irrelevant choices can be seen as meaningful ways to express a learner's identity (Patall et al., 2008).

8. General discussion

Both the UMTM and the SDT underline the importance of a learners' motivation in the interaction with the instructional environment. However, when dealing with digital learning media, the goal of increasing motivation might be restricted to the design of the learning materials, since no instructor is present during learning. In this case, motivation-enhancing strategies are needed which can be implemented as effortlessly as possible. This study was able to show that providing

simple choice options without changing the learning content (i.e., a feigned choice) is such a design feature. Even if a provision of learning topic options is not possible because of the learning topic, learning-irrelevant options like the choice of background music might be sufficient to increase a perceived autonomy, intrinsic motivation and learning scores.

Interestingly, a mediation analysis of both intrinsic motivation and scores of perceived autonomy revealed that only autonomy mediates the process of choice on students' retention performance. It seems that autonomy is more directly connected with an increase in learning than the previously assumed, mediating factor of intrinsic motivation (Patall et al., 2008) in terms of a feigned choice paradigm. In conclusion, the perception of an increase in autonomy seems to be a stronger catalyst of an engagement in learning. In this vein, the choices in this study were only able to increase a decisional aspect of autonomy, suggesting a more cognitive processing of choice options. In this regard, choice appeared to affect the perceptions of cognitive load by decreasing intrinsic cognitive load, which is mainly connected with a task difficulty (Sweller, 2016).

8.1. Conclusion and implications

This study added important insights in the effects of choice in learning with digital media. For the first time, a separation between learning-relevant and learning-irrelevant choices was examined. Although both types of choice were able to increase motivation and retention, there are differences in their effects on transferring knowledge and affecting scores of external regulation and ICL. However, an increased ICL for relevant choices supports CLT-based research, since more information complexity normally leads to an increase in this type of load (Sweller, 2016). Independently from the relevance, the usage of choice options was found to be useful for the design of digital learning materials. This adds important theoretical implications for the field of choice effects. In addition, this study revealed a mediating role of autonomy on learning.

In terms of practical implications, the results need to be taken with caution because of the feigned choice paradigm used in the experiment. In educational settings, a feigned choice can have even detrimental effects when it is used too often. Nonetheless, the results of this study might help educational designers to increase a motivation to keep working with the instructional material by easily implementing simple choices without changing the learning content. However, in cases where a topic choice can be presented, the effects might be even stronger than learning-irrelevant choice options. This might also be the case for “real” topic choices in contrast to feigned choices. Regarding populations lacking independence, like primary school children, the effects of choice will especially help to raise a perception of autonomy.

8.2. Limitations and future directions

As our manipulation is based on a fraud (a feigned choice), we were able to ensure optimal internal validity. But, as a consequence, we have to sacrifice external validity. This might have led to differences in the effects on autonomy and motivation. Moreover, not every topic can be split in two or more choices options that lead to the same text. For example, a learning text about how chemical processes develop might be restricted to one topic only. In this case, the promising approach of irrelevant choice might help. In addition, the feigned choice might be apparent after several trials. This might lead to negative emotional reactions and decrease learners' performance (Flowerday & Shell, 2015). Since the current investigation deals with short-term effects of motivation on learning, the long-term effects of choice are not predictable (e.g., Schweppe, Eitel, & Rummer, 2015). This also might have caused the differences in the findings of the mediation analyses and should be examined more precisely in future studies. This comparison of groups with different number of choices or choice options might be particularly important for these studies.

Future studies should examine possible long-term benefits of choice on learning outcomes. In this study, only choices with two options were provided so that the effects might be different if the amount of choices increase (e.g., Patall et al., 2008). A large number of choice options might especially affect the ECL of learners, since the number of choice options might distract learners from their learning goal. Although this study replicated findings across two experiments, the comparability of the experiments might be limited as the age span and gender distribution differed. A more complex measurement of the retention and transfer constructs by additional measurements (e.g., open answer questions or application tasks) might verify the differences between these constructs. Future studies should examine if both variables can be verified as moderators of choice effects. Moreover, these studies should extend the number of participants in order to find a more detailed picture of all effects. Since choice options were found to affect learners' affective states (Flowerday & Shell, 2015), deeper insights in the intertwining of motivational and emotional design features might be helpful to examine more complex learning situations.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.learninstruc.2018.06.006.

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