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Journaling: A powerful Academic Writing Learning Tool

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Abstract:

Students who engage in writing-to-learn activities do a better job of grasping the concepts being taught. Students may use journaling as a powerful learning tool to better grasp a subject and hone their analytical thinking abilities. In this regard, we conducted two long-term field trials. To keep track of their progress, students in Study 1 completed a learning diary after each of their biology courses. Student understanding, interest and critical reflection were higher in the intervention group than the control group (n=25) at study's completion. Increased interest in the subject matter led to a more critical examination through journal writing. Students' motivation to develop their critical thinking abilities was examined in the second study. In addition to the cognitive and metacognitive prompts, the experimental condition's (n=13) journal writers also got a personal utility prompt. The students in the control group (n=11) received just cognitive and metacognitive tests. The experimental group exhibited a higher degree of interest and a better level of critical thinking when it came to a bioethical problem than the control group. It is clear from these research that journal writing has a positive impact on student learning and critical thinking about difficult scientific topics.

Keywords: Learning journals, comprehension, interest, critical reflection, science education

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According to Ford and Yore (2012), the purpose of science education is to help students, regardless of their past knowledge, grasp scientific concepts, think critically on scientific challenges, and establish a lifetime dedication to education (Ford and Yore, 2012; Salomon & Perkins, 1998). Tunnicliffe and Ueckert (2007). For example, in domains like human biology, where scientific knowledge builds up and shifts frequently, these goals are especially significant.. It's vital to look at tasks that help kids understand, reflect critically, and become excited about learning. Students in the subject of science have found writing-to-learn to be an useful tool for learning (Gunel, Hand, &Prain, 2007; Reynolds, Thaiss, Katkin, & Thompson, 2012; Webb, 2010). Studies show that even young students benefit much from journaling (Schmidt, Maier and Nückles, 2012); this seems to be true even for young students. Previous study has mostly concentrated on the impact of journal writing (e.g., Glogger et al., 2012; Schwonkeet al., 2012; Holzäpfel et al., 2012; Nückles et al., 2012; Renkl et al., 2012) on understanding. Recent studies show that keeping a learning journal might help students learn more than simply how to read better. This paper will make the case and explain how journal writing might assist students in middle and high school become more motivated and critical thinkers.

1. The effects of journal writing on comprehension, motivation, and introspection are investigated.

Composing essays or summaries has a positive effect on pupils' understanding of complicated topics in general (Bangert-Drowns, Hurley, & Wilkinson, 2004; Klein, 1999). Writers who use learning techniques (which allow for the integration of new learning information into the learner's preexisting cognitive representations) are particularly effective in transforming writing into a potent learning instrument, according to Nückles, Hübner, and Renkl (2009; 2012) (Mayer, 2002). Initiatives like the Science Writing Heuristic (SWH) show that writing-to-learn activities have a positive effect on learning when compared to normal writing assignments in a wide range of science disciplines and educational levels (Chen, Hand, & McDowell, 2013; Gunel et al., 2007; Martin & Hand, 2009). Writing-to-learn activities, according to Hand and colleagues, enhance the utilisation of deep learning processes. It has been suggested that writing-to-learn can be used to help students realise the three steps of self-regulated learning: planning, organising, and developing, and then checking their

comprehension thereafter. Individual goals and learning strategies are identified and then put into practise during the writing process as part of the planning phase. Some examples of this are structuring the learning materials (organisational methods) and relating new information to students' prior knowledge (for example, by generating comparisons or critically commenting on the learning contents) (elaboration strategies). Student monitoring helps them to discover their understanding gaps and devise remediation strategies to close them. "This is the writing process moving on to the next iteration of the circle of self-regulated learning," said Nückles, Zimmerman, and colleagues (2009; 2002).

In most cases, students are requested to recreate previously learned material in a learning journal. Using an outline, students may choose the most important and fascinating aspects of a topic, organise the information by creating an outline, then elaborate on the content by linking abstract ideas to actual experiences and articulating their own personal views and perspectives. While a student, you should be able to plan, monitor, and reflect on your learning process as you write. As a result, journal writing might be seen as a viable technique for encouraging students to employ cognitive and metacognitive processes (Berthold, Nückles, &Renkl, 2007; Glogger et al., 2012; Nückles et al., 2009; Nückles et al., 2012; Nückles et al., 2009). Learning activities are rarely undertaken by learners on their own will. Thus, it has been shown that providing journal writing tips is a good way to encourage students to write in their journals. When learners are prompted to use learning techniques they are capable of applying in concept but do not exhibit or demonstrate to an acceptable degree in practise, prompts are questions or clues. Prior journal writing studies (Berthold et al., 2007; Nückles, Dümer&Hübner&Renkl, 2010; Berthold et al., 2007; Berthold et al., 2007; Nückles et al., 2007) emphasised student involvement in organisation, elaboration, and understanding monitoring. An advantage of prompt journal writing over other learning tasks such as summative writing or concept mapping is that learners are encouraged to use both cognitive and metacognitive learning strategies at the same time. (Novak, 2010) (Novak, 2010; Franzke, Kintsch, Caccamise, Johnson, and Dooley, 2005; Novak, 2010). For example, Glogger et al. (2012) found that students who used both cognitive and metacognitive strategies in their journal writing performed better on tests of comprehension and long-term memory. Study after study in a wide range of subjects, including biology, mathematics, and

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psychology, has found that journal writing improves learning outcomes in both laboratory and field settings.

In addition to helping students better understand and retain course material, learning diaries give them several opportunities to consider how the material they're studying relates to their own life. Effort and persistence are more likely to be put into learning if learners see the topic as personally relevant, beneficial, or exciting (Schunk & Zimmerman, 2008; Wigfield, Eccles, Roeser, &Schiefele, 2008; Wolters, 2003). However, in scientific classes, students are frequently unable to recognise the connection between the curriculum and their own life (Assor, Kaplan, & Roth, 2002). To put it another way, learning results can be adversely affected by learners' lack of identification with the learning topic and their lack of desire for high-quality learning processes and the development of thought-out solutions to complicated science issues (Kirby and Lawson, 2012). (Belland, Kim, &Hannafin, 2013). Keeping a journal can help students better relate to the material they are studying.

Writing in a journal, according to Schmidt et al. (2012), can help students reflect on the personal significance of scientific ideas, which in turn increases their drive to study. As part of a learning diary project for a biology class, students aged thirteen and fourteen were asked to answer a personal-utility question in addition to the usual combination of cognitive and metacognitive questions. Students in the control condition received cognitive and metacognitive signals as well, but no personal-utility stimuli were administered. Researchers found that the personal-utility prompt was an effective technique for helping students think on the personal usefulness of the learning materials they encountered. Compared to students in the control condition, who did not have access to a personal-utility prompt, students in the journal writing condition reported greater levels of interest in biology and higher comprehension scores after six weeks of weekly entries. A topic's relevance and personal value can help students connect more easily with the material and, as a result, their interest in it will grow.

Being able to see one's own value and having a clear comprehension of the circumstance may both be important catalysts for critical thinking (Rigby, Deci, Patrick, & Ryan, 1992). Scientific literacy is an important component of science education's primary goal of developing critical thinking (Ash & Clayton, 2009; Ford & Yore, 2012). What is critical

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reflection? It is the process of critically reflecting on one's own thoughts and ideas in order to better comprehend one's own worldview (Ash & Clayton, 2009). Students can create a personal opinion about controversial scientific issues, such as whether or not antibiotic treatment should be used in specific circumstances, by applying critical thinking skills (Driver, Newton, and Osborne, 2000; Ford and Yore, 2012). What if, instead, I were to get a donor card? As a means of encouraging students to think critically about their own education, teachers often ask them to write argumentative essays. Students are required to make assertions and counterclaims, back them up with evidence, and summarise the topic in a final conclusion (Nussbaum & Schraw, 2007; Zohar &Nemet, 2002). Students' ability to comprehend information is improved when the information is presented in an argumentative manner (Wiley et al., 2009; Wiley & Voss, 1999). According to prior research (Nussbaum and Schraw, 2007), producing a cohesive argumentative essay that offers arguments and counterarguments in a balanced and integrated manner is a rhetorically challenging challenge for inexperienced writers. According to Nussbaum and Schraw (2008), interventions in persuasive and argumentative writing that focused on the structure of the text only resulted in minimal improvements in the argumentation quality. Argumentative essays, for example, adhere to a strict rhetorical framework, whereas learning journals don't. Flexible and expressive writing in a learning diary offers the student the freedom to determine whatever aspects of an educational experience are most important to him or her. Students with less writing experience may benefit from studying journal writing because of its low rhetorical demands, which enable critical thinking on disputed scientific issues, especially in the context of science education.

2. The current research consists of two parts.

In light of this, the current study sought to examine the impact of journal writing on students' understanding, interest in, and capacity for critical reflection on scientific subjects. Those who had completed their journal writing were split into two groups, while those who hadn't were kept together. As a consequence, we ran two quasi-experimental trials in regular high school biology classes, both of which were successful. As a starting point, we looked at how journal writing compared to more traditional assignment writing tasks influenced secondary science students' comprehension, curiosity (or "motivation to learn") and critical reflection. A

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second study investigated if journal writing's favourable effects might be improved even further by explicitly encouraging participants to write and reflect on their own personal relevance to the learning topic.

An experiment done by a group of 7th grade biology students in a German middle school was published by the journal Science for the first time. Journaling was a requirement for one class. Students were expected to keep journals throughout the semester. Students in the other course were required to complete a range of additional homework tasks during the intervention time (writing a summary, answering questions, and developing a concept-map). It was emphasised to the students in the control group that they should utilise the activities to reinforce and better understand the basic ideas of the learning subjects being given. When writing journal entries about their educational experiences, students in the journal writing course were given a variety of stimuli (see Table 1) that encouraged them to employ cognitive and metacognitive skills. Students who received both cognitive and metacognitive prompts were predicted to outperform those who received only cognitive prompts in the journal writing condition. This is because our previous journal writing research had shown that a combination of cognitive and metacognitive prompts, in particular, strongly promoted deep comprehension and sustained retention. They were more motivated and able to develop a reflected position on a topic-related, controversial issue than the students who participated in the traditional homework condition because the students in the learning journal condition considered the learning content to be more interesting. As a result of this, we predicted that students in the journal-writing condition would be better able to think critically about the complex and contentious character of the learning content, for example, by formulating alternative ideas or challenging a perspective.

It was the researchers' aim that by asking students to reflect on the personal significance of the topics they discussed in their learning journal, they may improve the predictability even more of the first study's results in the second study. As a result, we conducted yet another quasi-experimental study with a group of students in two philosophy classes at a German high school (10th grade). All students were asked to keep a learning diary over the course of several weeks in which they were prompted by a combination of cognitive and metacognitive signals. But students were also given a personal utility task in the experimental condition,

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which asked them to write on how the subject matter was important to their own lives. Therefore, we expected that students who were asked to write on the topic's personal importance would find it more interesting and relevant. Because of their heightened curiosity, students should want to understand everything that they can about a disputed topic and, as a result, enhance their readiness to critically think about it.

3. STUDY NO. 1

Middle school students were compared to students who completed conventional biology homework assignments by doing journal writing accompanied by cognitive and metacognitive prompts in a quasi-experimental field research.

3.1 Participants and design of the method

There were 46 students (7th grade, ages 13-14) who took part in the quasi-experimental field research. In a tiny town in southern Germany, roughly 800 students and 75 instructors attended a high school with two biology classrooms at the time (about 12.000 residents). Immunology was the primary subject of biology studies throughout the time period in question (e.g., the functioning of white blood cells). After the introduction of sexual education, immunology was included into the larger topic of human biology. During the three weeks of the study, students in one class kept a learning journal in which they recorded their thoughts and reflections on the lessons they had just learned in biology. This led to a total of three entries (n = 21; 10 girls and 11 boys; 4 participants who were not born in Germany) reflecting on their experiences in class. Students in a different class were required to write regular learning diary entries as follow-up course work for three weeks, resulting in a total of 10 entries. As a follow-up course work assignment, standard homework (see the content component) was given to the other class (n = 25, with 15 females and 10 boys and 5 participants born outside Germany).

Our design was quasi-experimental in character due to the fact that students from a single class were assigned to either the experimental or control conditions. Taking into consideration differences between the pretest and posttest is therefore critical. Each participant had gone through the same two years of biology instruction as the others, with the same learning objectives. X2 (N = 46) = 0.71 for gender, F(1, 44) = 0.03 for age, and X2 (N = 46) = 0.01, ns for ethnic background also showed they were comparable. The findings of

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the pre-test score analyses showed that the students' previous knowledge scores, F(1, 44) = 0.38, ns, and their interest scores in the pre-test, F(1, 44) = 1.36, ns, were comparable. The students' prior knowledge scores were likewise comparable, F(1, 44) = 0.38, ns. We also made an extra effort to keep the two situations as similar as feasible by having the same instructor train both children on the same topic during the intervention period. Both courses received exactly the same curriculum and were taught using the same techniques. Post-testing comprised comprehension exercises, a critical reflection activity, and a question on the students' interest in the topic of the post-test. After the intervention phase, the posttest was administered immediately and again eight weeks later.

Materials

A 300-word introduction to the process of producing a learning diary was given to the 7th-grade students who participated in the study since they had no prior experience with journal writing. An emphasis was placed by the lecturer on putting the knowledge gained from the course materials into practise. In order to make journal writing simpler, instruction included two cognitive and two metacognitive prompts that promoted elaboration and organising procedures, as well as two metacognitive prompts that stimulated comprehension monitoring and preparation of corrective measures (see Table 1). No more teaching was given since an earlier research with a comparable age group found that kids can benefit from journal writing even without much training (e.g., Schmidt et al., 2012). Student learning diaries should be used to help students better comprehend the material they are studying. Each submission had an average word count of 82 words, with a standard deviation of 8.50 words. A research assistant recorded how many statements in the learning journals indicated that a learning strategy was being utilised in order to evaluate if our therapy was having the desired effect (for a detailed description of the coding system see Study 2). There were on average 2.85 (standard deviation 1.01) organisational strategies, 1.83 (standard deviation 0.81) expository strategies, and 1.52 (standard deviation 0.85) meta-cognitive strategies invoked by students in their learning diaries. In comparison, these sounds have low frequencies. Although journal writing was intended to help students structure and enhance their comprehension of the topic, students instead used it to merely repeat and regurgitate information they had been taught in

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class. Because they had obviously demonstrated some use of the indicated learning methods, we concluded that the therapy had been carried out as expected.

During the first week of class, students who were assigned conventional homework had to reread and summarise the material given during the lecture. Second, during the next week, they were required to summarise the lecture's main points in a concept map, sketch, or graphic. In the third and final weeks of the course, they were asked to reply to questions about the topic. To test this, we hypothesised that the activities (summary and concept mapping) would primarily activate organisational techniques since they required students to select the important concepts from a book and lesson, paraphrase, and organise them in a systematic fashion (in the case of summarising) (in concept-mapping). neither task clearly promoted or discouraged critical reflection, but they did not explicitly restrict such behaviours either. Answering preset questions was mostly about reinforcing previously learned material. Responding to questions was found to be the most effective method of fostering metacognitive experiences, particularly when students had difficulties answering the question. A quick introduction to summarising and concept mapping was given to students so that they could make the most of these learning exercises (about 200 words).

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Table 1. Prompts used in the writing instructions

Prompts	
Cognitive Prompts (Organization and Elaboration)	How can you structure and summarize the contents in a meaningful way?
	Which examples can you think of that illustrate, confirm or conflict with the learning contents?
Metacognitive Prompts (Monitoring and Planning of Remedial Strategies)	Which main points do you now understand, and which haven't you understood?
	What possibilities do you have to overcome your comprehension problems?
Personal-utility Prompt	Why is the learning material personally relevant for you at present or in future out of school?

Note. Students in Study 1 and students in the standard prompts condition in Study 2 received only the cognitive and metacognitive prompts. Students in the personal-utility prompt condition in Study 2 additionally received the personal-utility prompt.

Measures that are dependent

We devised a comprehension exam based on German high school biology curriculum standards to assess students' grasp of immunology. It was tested by two experienced biology instructors to ensure that it was curricularly legitimate (teaching experience 8 and 10 years). Both classes needed to be taught by professors to make sure that the activities' content was properly integrated into the class's biology sessions. Because the curriculum emphasises scientific literacy, such as the capacity to explain biological events scientifically, we devised explanation activities that tested understanding (e.g., "Explain the similarities and differences between an infection with bacteria and a virus" or "Explain what happens in the organism after an active immunisation"). As a result, students had to use what they'd learned in class to come up with explanations. The responses of the pupils were compared to the teacher's reference answers, and a trained research assistant who was unaware of the experimental conditions counted the number of right statements offered. One can get up to 18 points by answering all seven test questions properly.

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Students were asked to write a short answer on the topic of "Should patients who show symptoms such as coughing and fever be administered with antibiotics?" in order to test their critical thinking skills on a difficult disputed matter. We appreciate you taking the time to write a quick remark and to explain your position. " When it comes to causal structure the subject matter has enough depth to warrant further investigation. During the intervention session, the participants were taught the relevant information they required to reflect on the subject matter. ' The subject has to be open to a variety of viewpoints, and we wanted to make sure that it could be controversially debated. Two untrained research assistants assessed the students' ability to self-reflect in a classroom environment that was not made clear to them. Phase one involved compiling all responses to the question and then evaluating each one as evidence of critical thinking by justifying or criticising each remark. A 5-point grading scale from 1 to 5 was used to rate the quality of the students' remarks in the second phase on a scale from 1 to 5. (high quality). The following table shows the many tiers of this rating scale. Interpreter dependability was found to be fairly high, with an ICC of.92, according to the intra-class coefficient (ICC).

Table 2. Description of the quality ratings

Level	Description
1	Students neither provided any reasons to justify a position nor did they criticize a position.
2	Students provided few and low elaborated arguments to justify a position. They did not criticize a position.
3	Students provided at least one elaborated argument for one position and questioned the other position.
4	Students provided at least one elaborated argument for each position and reflected on the validity of the arguments.
5	Students provided elaborated arguments for both positions and integrated them into a reflected overall conclusion by weighing, synthesizing or refuting arguments.

Students' interest in immunology was gauged using the Intrinsic Motivation Inventory (IMI; Deci & Ryan, 2006), which we translated and adapted for the purpose of this research. Five self-report comments were assessed on a scale of one to five, with one being highly dissatisfied and five being completely satisfied (for example, "I love discussing

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immunological concerns a great deal."). A high interest score indicates that students enjoy debating difficult immunology topics and are excited about the course's contents. In terms of internal consistency, Cronbach's alpha was.77, which indicated that the results were good.

Procedure

Over the course of thirteen weeks, the complete research was conducted. During the first week of class, both sets of students were given pre-testing to see if they were interested in and knowledgeable about immunology. The outcomes of the two groups were compared. During the second, third, and fourth weeks of the course, students took immunology twice a week with the same teacher using the same materials, methodology, and subject each time. Both groups had to do their homework (journal writing or conventional chores) once a week, which resulted in three journal entries or three regular homework projects each week. Students in both circumstances were handed a sheet of paper with instructions on how to complete their future homework assignments. The instructor collected the students' homework each week to make sure they had done it. For this reason, we opted to withhold feedback from students in order to keep the execution of the intervention as objective as possible. Taking an exam evaluated by an instructor on immunology did not bring the topic to an end, though. This meant that the students in both conditions had no explicit, extrinsic motivation.

In the fifth week of class, all students were given a post-test that was identical to the protest. Between the fifth and thirteenth weeks of the semester, students were taught about different biological subjects (such as sexual education). The children in both classrooms were still taught similarly by the same teacher, who employed the same strategies and resources in both settings (traditional in both classes). In the 13th week, the post-test was given once more, this time with a critical thinking problem. The testing circumstances were uniform because we checked to see that they were all the same across the board. Paper-and-pencil assessments were administered to students in a typical biology class, who were ignorant of the experimental conditions. After the delayed post-test, the students in the typical homework condition were exposed to journal writing in order to profit from journal writing as useful follow-up course work and after the completion of the study.

3.2 Discussion of the Findings

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There are two experimental settings, each with its own set of averages and standard deviations shown in Table 3. We used partial 2 qualifying values, with values less than.06 indicating a little effect, values between.06 and.13 suggesting a medium effect, and values larger than.13 indicating a big effect (see Cohen, 1988).

Comprehension

RMANOVA was performed to examine the pupils' understanding gains over time. Pretest and posttest results were employed as within-subjects variables and the experimental condition as a between-subjects factor to examine students' understanding gains. Both experimental condition and time were found to have a significant impact on comprehension; the latter was found to have an effect of F(1, 44) = 31.09, p.01, partial 2 =.41 and the former was found to have an effect of F(1, 44) = 9.34, p.01, partial 2 =.18, indicating an increase in comprehension across the board in both conditions. F(1, 44) = 24.17 p.01, partial p2 =.36 must be taken into account in conjunction with the main impact of time and experimental condition, F(1, 44) = 24.17, p.01. When the interaction effect was analysed, it was shown that students in the learning diary condition learned much more than students in the normal homework condition throughout their intervention period (see Table 3).

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Table 3. Descriptive statistics of dependent variable separately for the three points of measurement and each experimental condition in Study 1

		Experimental Conditions					
		Traditional Homework			Journal Writing		
Variables		Pretest $n = 25$	Posttest $n = 25$	Delayed Posttest $n = 25$	Pretest $n = 21$	Posttest $n = 21$	Delayed Posttest $n = 20$
Comprehension[a]	*M*	5.66	5.88	6.42	6.05	9.55	9.90
	SD	1.81	2.47	2.35	(2.46)	3.22	3.61
Overall reflection[b]	*M*			1.25			1.95
	SD			0.74			0.50
Reflection Quality[c]	*M*			2.38			2.86
	SD			0.92			0.79
Interest [c]	*M*	2.54	2.84	2.65	2.56	3.06	3.23
	SD	0.57	0.65	0.51	0.72	0.49	0.58

Note. a is the average number of correct answers (a maximum of 18 points was possible); b is the average number of statements coded as critical reflection; c was rated on a five point rating scale (1-5).

It is important to do a delayed posttest to see whether there have been any changes in the two conditions over the course of a week. As a consequence, we conducted a second repeated measure analysis of variance utilising the immediate posttest and the delayed posttest as within-subjects factors and the experimental condition as a between-subjects factor in the immediate posttest and delayed posttest. F(1, 43)=1.94, p.005, partial p2=.004, suggesting that knowledge scores grew somewhat between the second and third measurement points, revealed statistical analysis. Furthermore, experimental condition had a significant main effect: F(1, 43) = 19.29, p.01, and partial p2 =.31 and p2 =.31. With F(1, 43) = 0.04, ns, and partial 2 =.00 for the time x experimental condition interaction, it was determined that the interaction effect was not statistically significant. There was some improvement in students' ability to comprehend in each of these situations. Students in the journal writing class outperformed their counterparts in the standard assignment class around two months after the research began, despite the fact that the group differences remained stable over time.

A pondering on the topic matter

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Eight weeks after the intervention period, we conducted a one-factor analysis of variance to see whether students in the journal writing class were better able to reflect on a complex, controversial issue in immunology than students in the traditional homework class. The dependent variable was the number of all statements students used to question, justify or criticise a position (i.e. overall reflection; see Table 3). (see Figure 1). F(1, 43) = 3.48, ns, partial 2 =.08, showing that the difference between the experimental conditions was not statistically significant. Nevertheless, in a second one-factor analysis of variance, in which the quality ratings were the dependent variable and the experimental conditions were the independent variable, F(1, 43) = 13.61, p.01, and a partial p2 =.24 demonstrated a significant main impact of the experimental condition. The second one-factor analysis yielded the following results: Students' remarks in the journal-writing condition were more critical than those in the standard assignment condition, as shown by a comparison between the two groups (see Table 3).

Interest

The pre- and posttest interest ratings were used as within-subjects factors and the experimental conditions were used as a between-subjects factor in a repeated measure analysis of variance in order to identify a possible rise in students' interest over the intervention period. Main effect: F(1, 44) = 8.11, P.01, and partial effect: F(1, 44) =.16, P = 0.01. Experimentation conditions were determined to have no statistical significance for the main impact or for an interaction effect between time and the experimental condition. Students' enthusiasm for immunology rose as a result of this (see Table 3). Between the journal writing condition and the other conditions, no change was found. The delayed measurement in this scenario would tell whether or not the effects on interest were stable in future weeks following the intervention period. A second repeated measure analysis of variance was performed, with the experimental condition serving as a between-subjects factor and the second and third interest ratings serving as within-subjects factors, as a consequence of which. F(1, 43) = 0.00, ns showed no significant main influence of time, while partial 2 =.00 showed a significant time effect. There was also a statistically significant interaction between time and experimental condition, F(1, 43) = 4.78 p.05, and the main effect of experimental condition was 7.30 p.05, with a partial 2 =.15, which was statistically

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significant. However, the interaction between time and experimental condition was statistically insignificant. During the intervention period, students' interest in immunology increased even more than in the standard assignment condition, which dropped once students completed immunology in school and reverted to pre-test levels. Student interest in biological topics was found via journal writing to have a greater long-term impact than short-term course activities such as summarising, idea mapping, or responding to questions.

Establishing connections between understanding, interest and critical reflection can be done.

We did a mediation analysis (see Baron and Kenny, 1986) to examine if journal writing enhanced students' understanding and, as a result, their interest in the issue, because we hypothesised that better understanding would raise students' interest in the topic. First, we ran a regression analysis on the dependent variable (interest score on the postponed exam) to see if our hypothesis held up (experimental condition). Learner interest was significantly affected by the experimental condition, with a t(43) of 3.59 and ß of.48. In the second stage, we ran a regression analysis on the predictor using the potential mediator (the delayed test's comprehension score) (experimental conditions). Experimentation showed a statistically significant influence on understanding, with t(43) = 3.90; ß =.51; and P =.01. Thirdly, interest was regressed on the predictor (experimental condition) and mediator (involvement in the experiment) to arrive at the final results (comprehension). Comprehending the material had a substantial impact on interest (t(42) = 2.43; ß =.36; p =.05), but the experimental condition had a smaller impact (t(42) = 2.01, ß =.30; non-significant) than in step one (t(42) = 2.01; ß =.30; non-significant) than in step 1. They believe this pattern of data supports full mediation, meaning that the students' enhanced comprehension in the journal writing condition contributed causally to their increased interest in immunology.

To that end, we hypothesised that journaling would improve students' ability to critically reflect on their experiences by deepening their knowledge of and enthusiasm for the material. In order to evaluate this hypothesis, a second mediation analysis was conducted, using reflection quality as the dependent variable, experimental condition as the independent variable, and interest and comprehension as mediators. In step one, it was determined that the experimental condition had a statistically significant influence on reflection quality: t(43) = 3.69, ß =.49, and p.01. The experimental condition has previously been shown to influence

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interest and understanding in the prior mediation investigation. Only interest had a statistically significant influence on reflection quality, with t(41) = 2.43, ß =.37, and p =.05, whereas the effects of comprehension, with t(41) = 0.56, ß =.09, ns, and experimental condition, with t(41) = 1.52, ß =.25, p =.05, failed to achieve statistical significance. According to Baron and Kenny, we may conclude that interest worked as a mediator between the experimental condition and the quality of the reflected picture. According to a combination of the results from the two mediation experiments, journal writing improved understanding and improved understanding led to an increased interest in biology. Curiosity fueled critical reflection, but understanding alone had no positive effect on critical reflection other from the one already described in the preceding paragraph.

4. STUDY NO. 2

Journal writing is a more effective learning-to-write activity in scientific education than typical writing assignments, according to the findings of the first study, since it encourages deeper knowledge, interest in the themes, and critical reflection. On the other hand, the positive effects of journal writing on student interest took time to emerge. As a result, we aimed to pique students' interest in the topic covered in their learning diary by encouraging them to consider the issue's personal relevance. This encouragement was expected to boost the topic's perceived relevance and interest. Furthermore, we expected that enhanced attention would stimulate critical thinking, based on the findings of Study 1. To do so, we compared students who responded to a mix of cognitive and metacognitive prompts in their diaries with students who additionally received a personal-utility prompt as an extra prompt. In response to this prompt, the students were asked to think about and write about the topic's personal utility or significance.

4.1 Participants and design of the method

Quasi-experimental field research participants, aged 16-17 in the 10th grade, took part in a field setting. It was in a little town in southern Germany where they lived that they taught philosophy to a high school of roughly 1100 pupils with 81 teachers (about 25.000 residents). An experimental design with two experimental conditions was employed to examine our research question. There were six men and five females and one non-German-born student in the class (n = 11 students; standard prompts condition; n = 11 students; 6 guys, 5 girls, and 1

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non-German-born student). Alternatively, in the second class, students received a personal-utility prompt in addition to the combination of cognitive and metacognitive prompts (personal-utility prompt condition; n = 13, including 6 males and 7 girls, as well as one boy and one girl who were not born in Germany). It is safe to say that our study was quasi-experimental in nature because each class was randomly allocated to either the experimental or the control condition. But the students who participated in the study had all been exposed to the same philosophy curriculum for three years, with the same learning objectives. Students' gender, age, ethnicity, and grades in philosophy were all equal (X2 [N = 24] = 0.17], while their interest scores before the intervention period were all equal (F(1, 22) = 0.22), as were their grades in philosophy and their F(1, 22) [N = 24] grades. "biology and ethical decisions" were covered by the poll's six-week period of study (e.g., pros and cons of genetic manipulation). Throughout the semester, they were all taught by the same philosophy instructor, who utilised the same teaching methods and materials. Immediately following each philosophy lecture, students were given 20 minutes to write a learning journal entry in their learning journals to reflect on what they had just learned. Because the learning diaries were included in class, it was easier for teachers to keep track of how much time each student spent on each assignment and to compare student progress across classes. There was a standard variation of 48.50 words in the average length of a learning journal post. Understanding of basic biological concepts, critical thinking skills, and a desire to participate in controversial topics were all examined as dependent variables. In addition, we examined the frequency with which different types of learning methods were utilised in the learning journals.

This study makes use of a variety of tools and metrics.

There was only one difference between this assignment and the one used in Study 1: the subject. Students in the personal-utility-prompt condition were also given a personal-utility prompt, which invited them to think about the topic's relevance to their own personal lives. It is shown in Table 1 how to respond to the two different scenarios.

It was determined whether or not the subjects were helpful and interesting by having students complete a motivation questionnaire that was administered to all of the students. Ten items from the intrinsic motivation inventory's value and interest scale were translated and adjusted

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for the current study, and these items were then employed as (IMI; Deci & Ryan, 2006). Items like "I found the biology-related topics in Philosophy to be quite interesting" and "I believe it is really important to discuss ethical issues in biology" were included. There had to be a 7-point rating system, with 0 being the lowest degree of agreement and 6 the greatest, in order for the objects to be evaluated (very high degree of agreement). Because of the high level of internal consistency (Cronbach's alpha =.82), we were able to calculate an average intrinsic motivation score for each student for both the pretest and post-test periods.

Students were tested on their knowledge of organ donation's legal foundations as well as standard operational procedures over the course of the comprehension assessment. Students in the philosophy programme learned a lot about this topic in-depth. Students might receive a maximum of six points if their responses were in line with the reference answers provided by their philosophy teacher.

Organ donation has both pros and downsides, and students were tasked with writing a brief essay on the subject to gauge their critical thinking abilities. The average number of words in the students' remarks was 102.54 (standard deviation = 28.90). In order to quantify critical reflection, we measured the number of topic-related statements that were supported by evidence or reasons (founded claims) and the number of topic-related statements that were not supported by evidence or reasons (unfounded claims) (unfounded claims). We assessed the comments on a five-point scale from 1 (poor quality) to 5 (great quality), just like we graded the comments in Study 1 (see Figure 1).

For the experiment's post-test outcomes, we aimed to identify learning approaches that could have contributed to them.. Therefore, we used and modified an existing coding method created by Nückles and colleagues. As a matter of fact, I am (2009). When it came to coding the learning diaries, we used two separate raters who each rated a single sentence. There were three sorts of statements: elaboration and metacognition were grouped together. In this situation, comments that emphasised the most essential aspects of the issue and how they interacted with one another were categorised as indications of organisational behaviour (e.g., students underlined important terms or highlighted them in different colors). We categorised statements in which students related the new topic to their previous knowledge, for example, by producing examples, analogies, or illustrations, in order to demonstrate their grasp. the

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purely cognitive elaboration was distinguished from the personal-utility statements (e.g., "It is important for me to know how medical practitioners diagnose a brain death.") because the personal-utility statements included motivational aspects and they were triggered by personal relevance and importance of the topic (e.g., "It is important for me to know how medical practitioners diagnose a brain death.") We coded statements like "I am having difficulty understanding the differences between active and passive immunizations," and "I am having difficulty understanding the differences between active and passive immunizations," as metacognitive strategies and remedial strategy planning (for example, "I am going to rework the course materials and ask the teacher if I am not understanding everything."). Information from the courses was not encased in any code at all. In terms of Cohen's Kappa dependability, scores ranged from.88 for organisation to 1.0 for personal utility, with the greatest value coming from the latter.

Procedure

A total of eight weeks were dedicated to this programme. Class one received the usual prompts condition and class two received the personal-utility prompt condition; both classes were allocated to class one. For both groups, we had them take the intrinsic motivation survey during our first week of class That was followed by a lesson on how to compose a diary entry. Personal-utility prompts were exclusively given to students in the personal-utility prompt condition, and were not given to students in the other conditions of the course. At the end of each of the two philosophy classes, students were obliged to submit a learning journal entry for six weeks following the conclusion of the classes. In class, pupils were given 20 minutes to finish the journal entries, which they did. Neither the students, nor anyone else, got the six journal entries. In class last week, all students were expected to take a post-test, which they did. The same questionnaire that was used for the pre-test was utilised to determine the degree of interest of the students. For the comprehension exam and critical reflection activity, they were also expected to answer questions on their comprehension. Research assistants in a regular philosophy class gave the examinations in a paper-and-pencil manner with no awareness of the experimental conditions. Students were not given a graded test on "human biology and ethical decisions" since it was not finished. There was no explicit or extrinsic motivation for the youngsters as a result. To ensure that students writing

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subsequent learning diaries benefit from this better teaching, the control group got an extra session of training that contained the personal-utility prompt immediately following its end..

4.2 Discussion of the Findings

Standard deviations are included in parentheses for clarity in the comparisons between the two experimental settings in Table 4.

An analysis of variance was undertaken to evaluate if the students in the personal-utility prompt condition perceived the topics to be more worthwhile or intriguing than those in the normal prompt condition, and whether this difference was statistically significant (P 0.05). This study found no significance for the main impacts of experimental condition or time (F(1, 22) = 0.69, ns, partial 2 =.03) or the major impact of time (F(1, 22) = 1.55, ns, partial 2 =.07). However, as expected, the interaction effect between time and experimental condition was significant, F(1, 22) = 6.83, p.05, partial p2 =.24 and the interaction effect between time and experimental condition was significant, F(1, 22) = 6.83, p 0.05, partial p2 =.24. Personal-utility prompt conditions saw an increase in interest, but interest in the traditional fast condition remained stable throughout the intervention period (see Table 4). Consequently, encouraging students to write on the personal significance of learning materials may boost their interest in the subjects.

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Table 4. Descriptive statistics of dependent variable separately for the experimental conditions

	Standard prompts condition n = 11		Personal-utility prompt condition n = 13	
	M	*SD*	*M*	*SD*
Interest in Pretest[a]	4.61	0.48	4.68	0.72
Interest in Posttest[a]	4.45	0.53	4.99	0.71
Comprehension[b]	4.36	1.21	4.85	1.07
Critical Reflection				
Unfounded Claims[c]	1.45	1.04	1.54	1.05
Founded Claims[c]	1.27	0.79	2.31	0.75
Quality Rating[d]	2.36	0.92	3.69	0.75
Statements in the learning journals				
Personal Utility[c]	0.73	0.61	1.58	0.67
Cognitive Elaboration[c]	1.00	0.68	1.41	0.70
Organization[c]	1.06	0.46	0.72	0.34
Metacognition[c]	1.11	0.86	2.38	1.94

Note. a was rated on a seven point rating scale (0-6); b is the average number of correct answers (a maximum of 6 points was possible); c is the average number of statements per entry; d was rated on a five point rating scale (1-5).

Comprehension

We used an analysis of variance to see if students in the personal-utility prompt condition had a greater degree of comprehension than students in the conventional prompt condition. There were no statistically significant changes in the experimental conditions, according to the data ($F(1, 22) = 1.08$, ns, partial 2 =.05.) The results, on the other hand, revealed that both conditions had high levels of comprehension (see Table 4).

Discussion on the topic

Following that, the students' comments on the benefits and drawbacks of organ donation were analysed. First, we investigated whether students reached a firm conclusion. When asked to reply to the personal-utility rapid condition, 77% of students provided a final conclusion (2 students decided against and 8 students for an organ donor card). In the usual prompts situation, 36% of students gave a final conclusion to the inquiry (all for an organ donor card).

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With X2 (N = 24) = 4.03 and a p-value of.05. the difference between the conditions was statistically significant. We utilised two analyses of variance to see if the students offered a different number of based and baseless assertions in the experimental circumstances. The overall number of baseless claims did not change between the circumstances, with F(1, 22) = 0.04, ns, and partial 2 =.00. We identified a statistically significant advantage for the personal-utility quick condition, F(1, 22) = 10.48, p.01, partial p2 =.33, and a large advantage for the personal-utility prompt condition, F(1, 22) = 10.48, p.01, partial p2 =.33, for founded claims. (Table 4) The quality of critical reflection was then investigated using a third analysis of variance, with the quality ratings serving as the dependent variable and the experimental condition serving as the independent variable. With F(1, 22) = 15.11, p.01 and partial 2 =.41, students in the personal-utility quick condition showed a statistically significant advantage. As indicated in Table 1, students in the personal-utility prompt condition had a higher level of critical thinking and provided a conclusion more often than students in the standards prompt condition.

You can record your learning techniques in the learning diaries. We utilised analyses of variance to see if students in the personal-utility prompt condition employed different learning techniques than students in the regular prompt condition. The experimental settings were employed as the independent variable, while the types of learning techniques were used as the dependent variables. Students in the personal-utility prompt condition wrote on the topic's personal relevance much more often than those in the regular prompt condition, F(1, 22) = 10.46, P =.001, partial p2 =.002. As a consequence, the intervention met its purpose. Students in the standard prompt condition used significantly more content organisation strategies than students in the personal utility prompt condition, F(1, 22) = 4.49, p =.05, partial p2 =.17, and students in the personal utility prompt condition used significantly less content organisation strategies (see Table 4). For simply cognitive elaboration approaches (F(1, 22) = 2.09, ns, partial 2 =.09) and metacognitive strategies (F(1, 22) = 4.07, ns, partial 2 =.16), we found no statistically significant differences in the experimental conditions.

Personal interests and critical reflection

We wondered if interest may operate as a mediating factor between the effect of the relevance prompt and the effect of critical reflection because the deployment of a relevance

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prompt raised both interest and critical reflection. In order to test this mediation hypothesis, the dependent variable was quality assessments of reflection, the independent variable was experimental condition, and the mediator was interest, and the results were positive. A substantial influence of experimental condition (predictor) on the students' quality of critical reflection (dependent variable) and an effect of experimental condition on interest in the posttest (mediator), t(22) = 2.08 and ß =.41, respectively, were found to be statistically significant. The interaction between interest and critical reflection quality was statistically significant when t(21) = 2.27, ß =.37, and p 0.05 were used to regress critical reflection quality on both predictors (experimental condition) and mediators (interest in the posttest). Although the effect of experimental condition was smaller than in step 1, it nevertheless approached statistical significance (t(21) = 2.96, ß =.49, p.001), which is consistent with the previous stage's findings. As a result, partial mediation might be assumed.

In general, the findings are as follows: As indicated by our findings in the control condition, students in the personal-utility prompt condition utilised their learning journals more frequently to self-explain the relevance of the learning materials by relying on their own experiences and building personal examples. Students exhibited a higher interest in the problem and improved their critical reflection abilities after considering their personal significance of a topic during journal writing. We discovered no statistically significant differences in their comprehension of the content, despite the fact that the students made substantially more well-founded assertions and engaged in high-quality comments. Because virtually all students scored well on the comprehension exam, this indicates that a standard set of cognitive and metacognitive signals was adequate to generate good results on the comprehension test. However, by encouraging students to think about how the issue relates to their own lives, the impact on curiosity and critical thought might be amplified even further.

5. Discussion on General Issues

The results of two quasi-experimental investigations, which are detailed in this paper, show that students' comprehension, interest in the topic they were obliged to write about, and their ability to critically reflect on an issue associated with the topic all improved after they wrote learning journals. We compared journal writing to a variety of different types of schoolwork in Study 1. Studies 1 and 2 were conducted to see if journal writing on curiosity and critical

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reflection might be bolstered even further by directing students to write on the personal importance of learning themes. The following are some broad conclusions to draw from the data:

5.1 Journal writing helps students improve their comprehension.

One research found that, on measures of comprehension, critical reflection, and self-reported interest in biology, students who kept a regular learning diary outperformed those who completed a range of other homework assignments such as concept mapping, summarising, and answering questions. Concept mapping (Novak, 2010) and summarising (Franzke et al., 2005) are two cognitive learning approaches that may be used to encourage the application of cognitive learning procedures, especially in organisational tactics. (e.g., identification and structuring of main ideas). Students were encouraged to employ both cognitive and metacognitive skills while writing their journal entries, which was a substantial benefit. Nonetheless, the prompted learning diary methodology has its advantages. Using this combination of cognitive and metacognitive techniques, we believe that students are more likely to engage in the whole cycle of self-regulated learning (Glogger et al., 2012; Nückles et al., 2009) based on past research. As a result, when students document their learning in a learning journal, they may better grasp the contents since they can organise and elaborate on the new knowledge. They may be able to identify and correct any gaps in their knowledge by employing remedial cognitive processes while evaluating their comprehension. Journal writing was shown to have improved comprehension ratings because of the employment of both cognitive and metacognitive processes throughout the writing process, which may have occurred from the joint use of both processes. However, even though students in the two groups utilised their learning diaries in somewhat different ways in the first study, adding a personal-utility challenge had no further favourable effect on comprehension. It was found that the students who were given the conventional prompts used more organisation strategies to structure their information while those in the personal-utility condition made more claims about their own connections with the issue Students in both scenarios performed similarly on the comprehension exam, resulting in equivalent but also high test scores on the test.

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Learners' identification with the learning topic is facilitated by prompt journal writing.

After performing traditional learning exercises, learners may not be able to identify themselves with the subject matter, and they may be unable to see the personal value of what they've learned (Kirby & Lawson, 2012). A series of concept mapping, summary writing, and question answering tasks throughout the course failed to ignite students' interest in the topic to the same degree that regular journal writing as follow-up course work did (Study 1). In the next paragraphs, we'll look at two possible causes for the rise in topical interest: In Study 1, students in the journaling condition had a better understanding of the problem. If you have a good grasp of a subject, you may be more likely to identify with and be interested in the subject (Schunk & Zimmerman, 2008). Study 1 validated our initial hypothesis, showing that the experimental condition's impact on interest was mediated by learners' understanding of the condition. In addition, while journal writing had an instant impact on understanding, it took time for journal writing to have a positive impact on students' engagement, which was most likely due to the improved comprehension. As a result, students' interest in the course subject may have been boosted by writing about the personal meaning of learning knowledge. So, in Study 2, we found that a significant increase in student engagement could be achieved by asking students to write about how the material they were studying was relevant to their life. Students who are able to recognise or elevate the personal relevance of a topic are more likely to have a lifelong interest in that subject and participate in conversation about it (Salomon & Perkins, 1998). In today's knowledge-based society, both independence and participation are essential, especially in fields like biology, where new and expanding scientific knowledge accumulates and changes at a rapid rate (Tunnicliffe&Ueckert, 2007).

5.3 Journal writing encourages critical thinking and reflection.

Research on journal writing in the past has focused on the application of cognitive and metacognitive methods to facilitate self-regulated learning (Berthold et al., 2007, Nückles et al., 2009 and 2010, Schmidt et al., 2012, Nückles et al., 2013 and 2014). Research has shown that improving students' recollection and understanding, as well as their willingness to study, has a positive effect. To teach middle and high school students to be able to address contentious issues and use logical thinking is one of the most important learning objectives in education (Ford & Yore, 2012). As a result, critical thinking, which includes voicing

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questions and competing ideas, is essential for students (Ash & Clayton, 2009). By allowing students to express themselves freely in their learning journals, teachers want to stimulate critical thinking and discussion about the pros and cons of difficult subjects based on their own personal interests and preferences (Nückles et al., 2009). However, previous research on journal writing has not focused on the importance of critical reflection as a learning result, which is an essential learning consequence, in the journal writing process itself. Consequently, in the current study, we investigated the influence of journal writing on students' capacity to critically reflect on a challenging subject in grades seven and ten. The findings of our present research show that students who wrote in a journal were better equipped to think critically about and resolve an ethical problem than students who did other homework tasks (Study 1). Learning to critically reflect requires more than just a solid grasp of the material; it also necessitates the learner's interest in the subject matter, which may be shown as an enthusiasm for the material. Students who view a topic as interesting and engaging are more likely to engage in critical thinking than students who view a topic as irrelevant or dull (Study 1 & 2). Students' ability to critically reflect on what they had learned was enhanced as a result of having a more personal connection to the material they were studying (Ford & Yore, 2012). In a way, our data show that journal writing supports a domino effect, starting with enhanced understanding and moving to increased engagement and critical thought.

6. Study stipulations and restrictions

A focus of our research was the use of journal writing in middle and high school science classes, specifically as a quasi-experimental, longitudinal field study. Given that both theoretical and practical considerations drove our study, we classify our findings as "use-inspired research" (Renkl, 2013). To maximise ecological validity while keeping the advantages of a laboratory study, we carried out experimental treatments in a real field situation (e.g., controlling for potential confounds). There are advantages and downsides to allocating entire classes to an experimental condition rather than randomly assigning individuals. Other uncontrolled confounds may have affected the intervention study results, despite the fact that we took into account students' pre-existing individual differences and possible confounds throughout the intervention research (such as teacher, teaching methods,

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materials, and time on task). Our findings must be replicated using genuine experimental designs in which students are randomly assigned to different experimental settings.

This is a key drawback of our current research, as the conclusions cannot be generalised to other fields. This is especially true in the case of human biology, where students instantly grasped the personal value of their studies. Because of this, we believe that the content domain's accessibility is a significant factor in the powerful impacts of the personal utility prompt shown in Study 2. With these findings in mind, it remains to be seen how well we'll fare when it comes time to apply our methods to more distant realms of study (e.g., particle acceleration in physics). Therefore, the findings must be replicated across a range of age groups and environments.

7. Ending thoughts

Studies like this one show that journal writing helps students build their critical thinking skills as well as a passion for learning and a desire to continue their education throughout their lives by fostering their comprehension of scientific concepts, topics, and concepts in general. For middle and high school students, journal writing proved to be more useful than other standard writing assignments for self-regulated learning in human biology than other traditional writing tasks. Using learning journals to assist students practise writing to learn has been recognised as a specific technique for fostering the growth of students' scientific literacy. Using learning diaries, students were able to practise the kinds of excellent learning practises that help students retain information better, increase their enthusiasm, and improve their critical thinking abilities. The favourable effect of journal writing on students' participation in the course was further strengthened by providing writing instruction that not only focused on cognitive and metacognitive processes, but also on motivational components, such as the personal significance of a specific problem. According to the findings of this study, journal writing has far-reaching advantages that go beyond merely helping students understand and retain course information. Learners' interest in difficult skills like critical reflection may be piqued and acquired with the help of learning diaries, according to this research.

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