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► **To cite this version:**

Mario Mäeots, Leo Siiman, Külli Kori, Mats Eelmets, Margus Pedaste, et al.. The Role of a Reflection Tool in Enhancing Students Reflection. 10th annual International Technology, Education and Development Conference (INTED 2016), Mar 2016, Valencia, Spain. hal-01399091

HAL Id: hal-01399091

<https://telearn.hal.science/hal-01399091v1>

Submitted on 18 Nov 2016

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Conference Paper · March 2016

DOI: 10.21125/inted.2016.1394

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THE ROLE OF A REFLECTION TOOL IN ENHANCING STUDENTS' REFLECTION

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Abstract

Reflection is a cognitive process that can help students understand and learn from their learning experiences. This implies thinking back about the course of learning processes in order to enable better behaviour and actions in the future. Reflection is more efficient if it is supported by technological tools. These tools offer the ability to present detailed information about learning processes (e.g., use of time during a specific learning process) and the ability to provide guidance, for example in the form of questions that support reflection. In this paper we present the results of a study carried out with 9th grade students (mean age 15.0 years, n=59) to clarify the role of a Reflection Tool to support students' reflection. The Reflection Tool in this study is a web-based application that was tailored for a chemistry-based Inquiry Learning Space (ILS) called "What does pH measure?". The ILS and Reflection Tool were developed as part of the EU funded project called Go-Lab (see www.go-lab-project.eu). Students were divided into two conditions. In experimental condition the Reflection Tool was used and in the control condition it was not. Furthermore, two types of devices were used to implement the Reflection Tool: tablets and personal computers. Assessment of the Reflection Tool was based on coding the response to open-ended questions that support reflection. Two aspects were assessed in students' reflections: content (technical, situational and sensitising) and reflection level (description, justification, critique, dialogue and transfer). A qualitative analysis and a non-parametric Mann-Whitney U-test were used to detect to what extent the Reflection Tool helps identify students' reflection content and levels. Although, there was no statistically significant difference in favour of the Reflection Tool, the results still showed that the Reflection Tool enabled to identify students' reflection content and levels. In this paper we discuss the possible interpretations of these results.

Keywords: reflection, scaffolding reflection, inquiry-based learning, online learning environments, web-based applications.

1 INTRODUCTION

Learning is more effective if a student is able to learn from his or her own learning experiences [1]. These experiences are better recalled through reflection that is structured, guided and supported by technological tools [2]. This study aims to clarify the role of an online Reflection Tool in supporting students' reflection in the context of inquiry-based learning. We report the results by comparing two conditions implemented with two types of devices: a) tablets and b) personal computers. In one condition the Reflection Tool was used (experimental group) and in the other condition it was not (control group).

1.1 Reflection

Reflection can be defined as a cognitive process carried out in order to learn from experiences through individual inquiry and collaboration with others [2–6]. The reflection process is important in education because it leads to deeper learning [5], helps create new relations between initial and acquired knowledge and makes the learning process more effective [7]. Therefore, adding a reflection process to different tasks in schoolwork helps support students' learning.

1.2 Levels and content of reflection

Researchers have identified reflection levels to differentiate and evaluate the quality of reflection. Based on previous studies [5, 8, 9], Leijen et al. [1] differentiated between four levels of reflection: description (descriptive information), justification (logic or rationale), critique (explanation and evaluation), and discussion (discussing alternative solutions for changing one's practice). The levels

are hierarchical: description is the lowest and discussion is the highest level. Also, every higher level contains the skills from a lower level [1]. Poldner et al. [10] further elaborated on the four reflection levels and created the following five levels: description (descriptions of the difficulties that the student had), justification (rationale or logical explanation for the difficulties), critique (explanation and evaluation of the difficulties), dialogue (critical review of different solutions or alternative methods), and transfer (how the next action becomes different or better than the previous action). These five levels were used in this study to assess level of students' reflections.

In addition to reflection levels, reflection has focus. Therefore, the content of reflection can be assessed. Leijen et al. [1] and Poldner et al. [10] described the content of reflection as being technical (technical aspects related to a task), situational (beliefs, feelings, values and habits regarding a task) and sensitising (wider social, moral, ethical, or political aspects of a task). In the current study students' reflections were also assessed using these three reflection content criteria.

1.3 Scaffolding reflection

Reflection is a challenging activity for students because what students think about their experience may differ from actual events [11]. This suggests that the reflection process needs to be supported [12-14]. With support, the reflection quality can be guided towards higher levels and the focus of reflection can be guided towards a broader social context [1].

One way to support reflection is by using technology [1, 15-17]. Technological tools offer guidance and the ability to present detailed information about the learning process (e.g., use of time during a specific learning process). Kori, Pedaste, Leijen, & Mäeots [18] reviewed studies from the years 2007–2012 and identified three types of reflection support that are used in technology-enhanced learning: technical tool, technical tool with predefined guidance, and technical tool with human interaction guidance. The technical tool with predefined guidance includes prompts and guiding questions. Reflection prompts in online learning can help students engage in reflection [16]. Also, reflection prompts can be used with guiding questions that offer cognitive and metacognitive support for students [19]. In the current study technical tools with predefined guidance (prompts and guiding questions) were used to support reflection.

1.4 Inquiry-based learning

Inquiry-based learning is a student-centred learning approach where students construct new knowledge by going through a sequence of inquiry phases [20-22]. Generally, these inquiry phases form an inquiry cycle while in specific phases there might be a need to turn back to previous stages and in the end of the process will often be specified new questions for the next inquiry cycle. In the current study we applied an online Inquiry Learning Space (see section 2.2.1) that follows an inquiry cycle introduced by Pedaste et al. [23]. According to the Pedaste et al. [23] inquiry cycle model there are five general inquiry phases: Orientation, Conceptualisation, Investigation, Conclusion, and Discussion. In the Orientation phase the domain topic is introduced and a research problem is identified. In the Conceptualisation phase theory-based research questions and/or hypotheses are formulated. The Investigation phase is for planning and conducting experiments to find answers to the formulated research questions or to accept or reject the stated hypotheses. Finally, in the Conclusion phase conclusions about the investigated research problem are made. In parallel or in the end of each phase or the conclusion phase there is the Discussion phase, where the results are communicated with others and reflective activities are applied. The latter is the focus of the current study. The aim of this study is to assess whether a Reflection Tool applied in the Discussion phase helps identify students' reflection levels and in comparison to a regular input box tool. Also, we aimed to identify potential differences between using the Reflection Tool in a tablet and in a personal computer.

2 METHODS

2.1 Materials

2.1.1 Inquiry Learning Space

An Inquiry Learning Space (ILS) is an online learning space hosted by the Go-Lab Portal (see <http://www.golabz.eu/spaces>). The Go-Lab Portal is one of the outcomes of the EU funded project Go-Lab (see www.go-lab-project.eu). Go-Lab provides opportunities to science teachers to create or

adapt their own ILSs. An ILS is an online learning environment in which students solve inquiry-based tasks using virtual or remote labs. Each inquiry phase in an ILS can be supported by specific learning applications (e.g., Concept Mapper, Hypothesis Scratchpad, Observation Tool, Conclusion Tool, Reflection Tool, etc.). In the current study we focused on clarifying the role of the Reflection Tool, which was designed to support students' reflection. The Reflection Tool was applied in a chemistry-based ILS called "What does pH measure?". This ILS contains five inquiry phases that follow the inquiry cycle introduced by Pedaste et al. [23]. In the beginning of the task—the Orientation phase—the domain subject and two research questions about the definition of pH and what happens when you add water to acidic or alkaline solution are introduced to the students. In the Conceptualisation phase students formulate hypotheses. After that, students enter the Investigation phase to conduct experiments to find evidence for confirming or rejecting their hypotheses. In this phase students use data collected from virtual labs called "The Acid-Base Solutions" and "pH Scale: Basics" that were created by the PhET project (<http://phet.colorado.edu>) and are integrated into the Go-Lab Portal. Next, students enter the Conclusion phase to make final conclusions about their experiment by confirming or rejecting their formulated hypotheses. As a final step, students use the Reflection Tool in the Discussion phase to reflect on their study process. The Reflection Tool is described in the following section.

2.1.2 Reflection Tool

The Reflection Tool aims to support and guide students' reflection. The Reflection Tool is a web-based application that can be integrated into a Go-Lab Inquiry Learning Space. Within an ILS it provides feedback to students about their use of time in each inquiry phase. The Reflection Tool displays the percentage of time a student spends in the various inquiry phases and compares this time to a norm set by the ILS creator (Go-Lab provides possibilities for teachers to design their own ILSs so that teachers can also change the settings of each Go-Lab application). Time planning is one of the sub-skills of regulative planning processes, helping students to control their learning [22, 24]. Thus, providing students an overview of their use of time is one way to support them in their learning. Also, it gives valuable feedback to the teacher about the flow of the study process (e.g., why a student did not manage to end a task on time). An example of the data presented by the Reflection Tool is presented in Fig. 1.

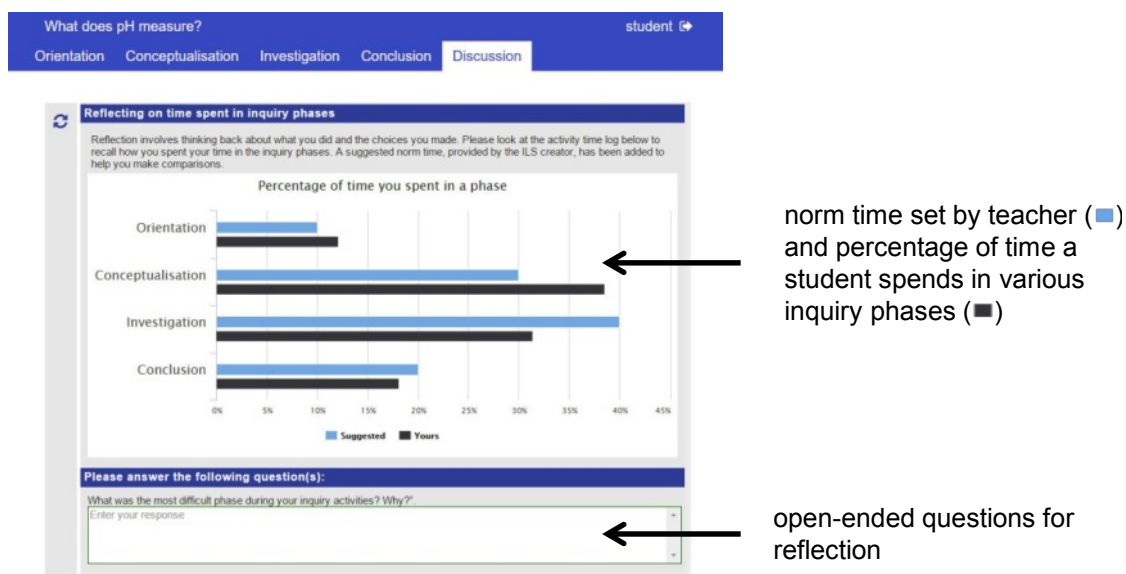


Fig. 1. Screenshot of the Reflection Tool

Secondly, students are prompted to reflect on their ILS use with open-ended questions. Questions asked in the Reflection Tool were "What was the most difficult phase during your inquiry activities? Why?". Combined with information displayed about time spent students can spot their difficulties in a specific inquiry phase. This type of reflective questions guides students to think about the course of the learning process and gives directions for similar situations in the future. The Reflection Tool is designed so that teachers can easily add, move or modify questions students reflect on.

2.2 Participants

The intervention was carried out in two Estonian public schools. Schools were selected with the aim of implementing the Reflection Tool with students using two different types of devices: a) tablets and b) personal computers. In total, there were 59 ninth grade students (mean age 15.0 years) participating in the current study. 38 students from one school worked with their school's tablets in a regular classroom and 21 students from the other school worked with personal computers in their school's computer lab.

2.3 Procedure

Two similar interventions were implemented in two schools with only one difference: at one school students used tablets and in the second school students used personal computers for solving an inquiry task using a Go-Lab Inquiry Learning Space. The length of each intervention was one school lesson (45 minutes). The intervention involved two conditions. In the first condition the Reflection Tool was included in the ILS called "What does pH measure?". In the second condition students did not have the Reflection Tool included. Instead, they had an input box tool (a web-based application that allows students to enter simple text) which allowed them to answer the open-ended reflection questions without the additional visual feedback about use of time that the Reflection Tool provides. The question for the second condition was exactly the same as in the first condition. Students were randomly placed into one of the two conditions. Considering different conditions and devices that students used four different groups were randomly formed. The groups are described in Table 1.

Table 1. Description of the randomly formed groups

Group	Device	Condition	No. of students
Tablet 1	Tablet	ILS with Reflection Tool	19
Tablet 2		ILS without Reflection Tool (replaced with input box tool)	19
PC 1	Personal computer	ILS with Reflection Tool	10
PC 2		ILS without Reflection Tool (replaced with input box tool)	11

Both interventions were led by a researcher involved in the Go-Lab project. The researcher's role was to take notes about the intervention and provide help, if necessary, with technical issues (e.g., repairing Wi-Fi connection).

2.4 Coding and assessing students' reflection

Two aspects were assessed in students' reflections: content and level. The content was assessed by the following scale: technical, situational and sensitising [1]. Reflections were categorised as technical if students pointed out technical difficulties that they had with a task. Reflections were categorised as situational if students pointed out difficulties that were related to the content of a task; and reflections were categorised as sensitising if students pointed out wider social, moral, ethical, or political aspects of a task. Table 2 gives an overview and provides examples of how the content of reflection was assessed.

Table 2. Assessment of the content of students' reflections

1	Description of the content	Example
Technical	Students pointed out technical difficulties that they had with a task.	"The whole task was difficult because the web-page crashed all the time."
Situational	Students pointed out difficulties that were related to the content of a task.	"Making conclusions was difficult because it was hard to formulate the sentences."
Sensitising	Students pointed out wider social, moral, ethical, or political aspects of a task.	"If I was not so tired, it would have been easier to concentrate; and I needed more time to understand everything."

Reflection quality was assessed based on the reflection levels developed by Poldner et al. [10]. Table 3 gives an overview and provides examples of how the levels of reflection were assessed.

Table 3. Assessment of the level of students' reflections

Reflection level	Description of the level	Example
Description	Descriptions of the difficulties that the student had	"None of the tasks were difficult for me".
Justification	Rationale or logical explanation for the difficulties	"Making inferences was difficult because I had to think what can be concluded from the experiment".
Critique	Explanation and evaluation of the difficulties	"The most difficult task for me was observation, because I understood what was going on, but I did not know how to write it down".
Dialogue	Critical review of different solutions or alternative methods	"Formulating a hypothesis was difficult, because I had to investigate both of the schemes and conclude what I saw; and it took a lot of time".
Transfer	Transfer knowledge of how the next action becomes different or better than the previous action	"Honestly, none of the tasks were difficult for me, but I think that task number 2 was more difficult than others. I would like to do one more task that helps to complement my results in tasks number 1 and 2".

Two researchers assessed the reflection content and levels independently and inter-rater reliability was calculated. In the case of reflection levels the value of Cohen's Kappa was 0.644 and in the case of reflection contents 0.634. The values suggest that the data analysis was reliable.

2.5 Data analysis

Given the relatively small sample size in different intervention groups the the quality of reflections in different groups was compared by nonparametric Mann–Whitney U-test.

3 RESULTS AND DISCUSSION

Our study focused on whether the Reflection Tool helps identify students' reflection content and their reflection levels. We compared the results between four groups described in Table 1. The outline of this results and discussion section is the following: first we describe and discuss students' reflection content, and in the second part of the section we discuss the results of the students' reflection levels.

3.1 Students' reflection content

As shown in Fig. 2, the reflection content of most of the students in all four groups was related to situational content. Closer examination of the students' reflections shows that the most common difficulties were problems with hypothesis formulation. It is an expected result because research on inquiry-based learning indicates that students encounter several problems while conducting inquiry-based learning [e.g., 22, 25]. For example, students reflected on issues concerning hypothesis formulation, such as *"For me it was difficult to formulate correct hypotheses because I did not know theory."* or *"Words I could use for constructing hypotheses were too long and confusing."* or *"I don't how to formulate hypotheses."* This also confirms findings from the literature [22]. Considering situational content we did not detect any statistically significant difference between experimental and control group.

A rather interesting result appeared considering technical content. The intervention group Tablet 1, who worked with tablets and used the Reflection Tool reflected more on technical issues than any other group (11 reflections on technical content). And if we compared the Tablet 1 group with the similar group PC 1 (they used personal computers instead of tablets) we found a statistically significant difference between these two groups ($Z=-2.2$; $p<0.05$). One example of technical reflection

content was “My iPad crashed all the time.” And if we analyse notes provided by the researcher who led the intervention we see that the tablet group had several issues with Wi-Fi; thus, the loading time for tools was longer. But the screen size of the tablet was also an issue because some parts of the Reflection Tool are partially hidden compared to the personal computers. Therefore, we detected an obstacle that needs solving.

Sensitising reflection content was related to personal issues such as “I feel that I am too tired to do this learning activity.” In all groups sensitising reflection content was reflected moderately.

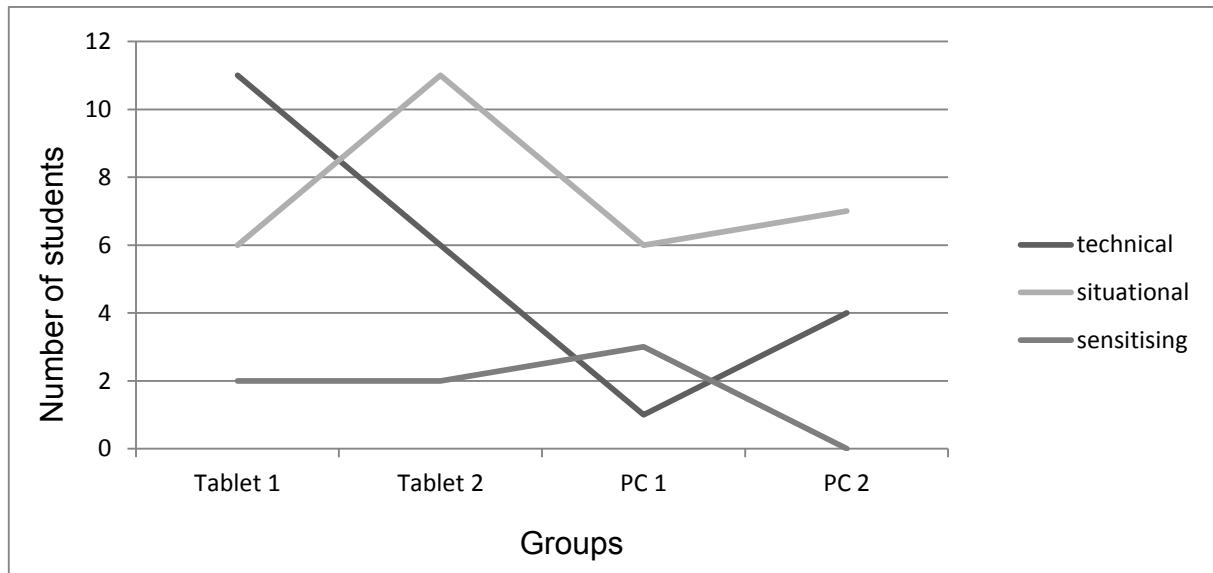


Fig. 2. Number of students categorised by reflection content for groups Tablet 1 (n=19), Tablet 2 (n=19), PC 1 (n=10) and PC 2 (n=11).

Considering the results we found evidence that the Reflection Tool enables to identify students’ reflection content. However, we detected only one significant difference and found no other statistically significant evidence in favour of the Reflection Tool. It seems that it happened because the content brings to attention factors that are not much related to time spent in inquiry phases.

3.2 Students’ reflection levels

The results addressing students’ reflection levels were analysed and compared between the intervention groups. Fig. 3 shows the distribution of students in the five different reflection level categories. In all intervention groups there were students that could be categorised into each of the five categories. In the Tablet 1 group most students were categorised into justification reflection level, whereas in the Tablet 2 group (students who used the ILS without the Reflection Tool) most students were categorised into the transfer level (i.e. the highest level). In the PC 1 group most students were divided between three reflection levels— justification, dialogue, and transfer—, three students on each. In the PC 2 group most students reflected on justification and critique level (see Fig. 3).

If we compare groups by device then there are more students on the highest two levels for Tablet 2 compared with the Tablet 1 group, and if we conduct a Mann-Whitney U-test then there is a statistically significant difference ($Z = -4.8$; $p < 0.05$) in favour of Tablet 2 (the condition without the Reflection Tool). This difference may be explained by the researcher observations made during the intervention and issues described in the previous section (see 3.1). We did not detect any statistically significant difference when we compared the PC groups. Therefore, we can assume that the statistically significant difference between the two Tablet groups is justified by technical issues that students met during their learning. First, the loading time of the Reflection Tool was longer and additionally the size of the tablet screen makes text in the tool appear smaller or harder to notice and requires scrolling.

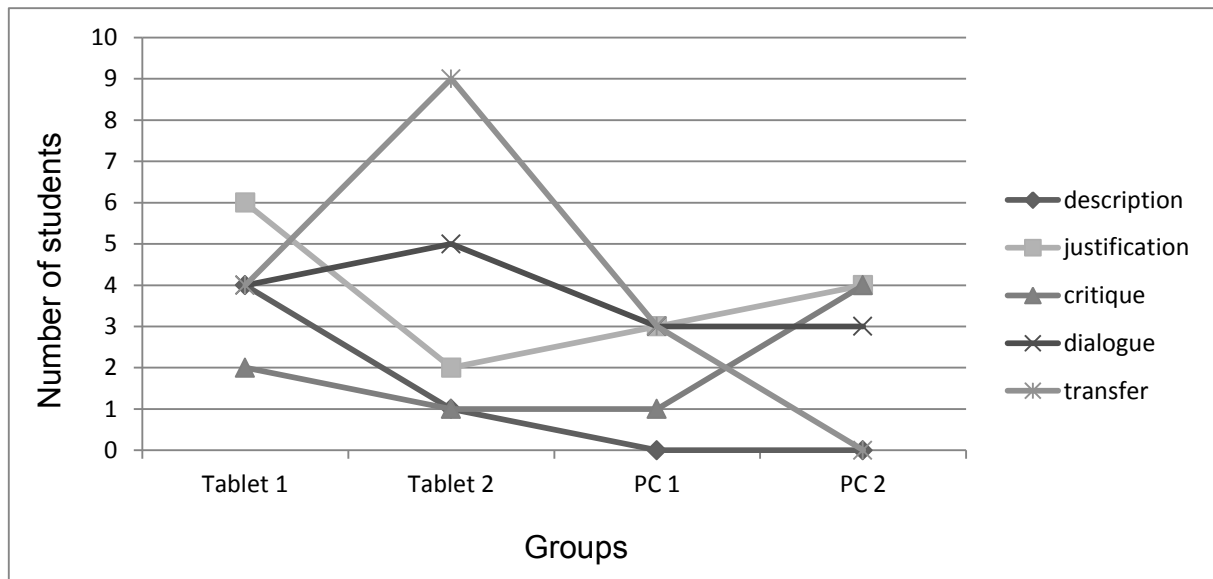


Fig. 3 Number of students categorised by reflection level for groups Tablet 1 (n=19), Tablet 2 (n=19), PC 1 (n=10) and PC 2 (n=11)

In order to identify the role of the Reflection Tool in supporting students' reflection we reorganised the intervention groups so that we could compare two conditions: a) ILS with the Reflection Tool (Tablet 1 + PC 1) and b) ILS without the Reflection Tool (Tablet 2 + PC 2). Contrary to expectations we see that in the group without the Reflection Tool there are more students on the higher reflection levels (dialogue and transfer) than in the group with the Reflection Tool. One possible reason for this, as surmised from the researchers' notes, is that students' motivation to answer reflection questions decreased due to lack of time (Reflection was the last phase in the inquiry process) or due to the technical problems that students encountered (there were more problems with internet connection in Tablet group). Although research claims that effective reflection can be achieved by using technology [16], there are still many obstacles to be considered while using, e.g., Wi-Fi.

4 CONCLUSIONS

The current study evaluated an initial version of the Reflection Tool used in tablet computers and personal computers. We aimed to find out to what extent the Reflection Tool would help identify students' reflection content and levels. However, we did not detect any statistically significant results in favour of the Reflection Tool in leading students' reflection on higher levels compared to an input box tool. Nevertheless, this study indicates that the general structure of a Go-Lab ILS offers an inquiry learning experience that is conducive to prompting student reflection and has a positive effect on identifying students' reflection content and reflection level.

We detected several technical issues to consider in conducting similar studies in the future. Considering that the Inquiry Learning Space can be further improved in order to avoid technical obstacles and subsequent demotivating issues that affect students' reflections, special attention must still be paid if using tablet computers with tools like the Reflection Tool.

The main limitations of this study are the following: a relatively small sample and reflections of the students were too short for making generalisations. Thus, improving the Reflection tool by adding more guiding questions to support reflection and increasing the sample is necessary in future studies.

ACKNOWLEDGMENTS

This study is funded by the European Union in the context of the Go-Lab project (Grant Agreement No. 317601) under the Information and Communication Technologies (ICT) theme of the 7th Framework Programme for R&D (FP7). This document does not represent the opinion of the European Union, and the European Union is not responsible for any use that might be made of its content.

REFERENCES

- [1] [Leijen, Ä.; Valtna, K.; Leijen, D. A. J.; & Pedaste, M. \(2012\). How to determine the quality of students' reflections? *Studies in Higher Education*, 37\(2\), 203-217.](#)
- [2] Benammar, K. (2004). *Conscious action through conscious thinking - Reflection Tools in experiential learning*. Public seminar. Amsterdam: Amsterdam University Press.
- [3] Dewey, J. (1933). *How we think*. Buffalo, NY: Prometheus Books.
- [4] [Mezirow, J. \(1991\). *Transformative dimensions of adult learning*. San Francisco, CA: Jossey-Bass.](#)
- [5] [Moon, J. A. \(2004\). *Reflection in learning and professional development*. New York: Routledge.](#)
- [6] [Schön, D. \(1983\). *The reflective practitioner: How professionals think in action*. New York: Basic Books.](#)
- [7] [Davis, E. A. \(2003\). Prompting middle school science students for productive reflection: Generic and directed prompts. *Journal of the Learning Sciences*, 12, 91-142.](#)
- [8] [Tsangaridou, N. & O'Sullivan, M. \(1994\). Using pedagogical reflective strategies to enhance reflection among preservice physical education teachers. *Journal of Teaching in Physical Education*, 14\(1\), 13-33.](#)
- [9] McCollum, S. (1997). *Insights into the process of guiding reflection during an early field experience of preservice teachers*. PhD Dissertation. Virginia Polytechnic Institute and State University.
- [10] [Poldner, E., Simons, P. R. J., Wijngaards, G., & Van der Schaaf, M. F. \(2012\). Quantitative content analysis procedures to analyse students' reflective essays: A methodological review of psychometric and edumetric aspects. *Educational Research Review*, 7\(1\), 19-37.](#)
- [11] [Argyris, C., & Schön, D. \(1974\). *Theory in practice. Increasing professional effectiveness*. San Francisco: Jossey-Bass.](#)
- [12] [Abou Baker El-Dib, M. \(2007\). Levels of reflection in action research. An overview and an assessment tool. *Teaching and Teacher Education*, 23\(1\), 24-35.](#)
- [13] [Lee, H. \(2005\). Understanding and assessing preservice teachers' reflective thinking. *Teaching and Teacher Education*, 21\(6\), 699-715.](#)
- [14] [Wade, R. C. \(1994\). Teacher education students' views on class discussion: Implications for fostering critical reflection. *Teaching and Teacher Education*, 10, 231-243.](#)
- [15] [Chen, N. S., Kinshuk Wei, C. W., & Liu, C. C. \(2011\). Effects of matching teaching strategy to thinking style on learner's quality of reflection in an online learning environment. *Computers & Education*, 56, 53-64.](#)
- [16] [Chen, N. S., Wei, C. W., Wu, K. T., & Uden, L. \(2009\). Effects of high level prompts and peer assessment on online learners' reflection levels. *Computers & Education*, 52, 283-291.](#)
- [17] [Hsieh, S. W., Jang, Y. R., Hwang, G. J., & Chen, N. S. \(2011\). Effects of teaching and learning styles on students' reflection levels for ubiquitous learning. *Computers & Education*, 57, 1194-1201.](#)
- [18] [Kori, K.; Pedaste, M.; Leijen, Ä.; Mäeots, M. \(2014\). Supporting reflection in technology-enhanced learning. *Educational Research Review*, 11, 45-55.](#)
- [19] [Ge, X. \(2001\). *Scaffolding students' problem-solving processes on an ill-structured task using question prompts and peer interactions*. Unpublished Doctoral Thesis. Retrieved January 19, 2016, from <https://etda.libraries.psu.edu/paper/5867/>.](#)
- [20] [Mäeots, M., & Pedaste, M. \(2014\). The role of general inquiry knowledge in enhancing students' transformative inquiry processes in a web-based learning environment. *Journal of Baltic Science Education*, 13, 19-31.](#)
- [21] [Mäkitalo-Siegl, K., Kohnle, C., & Fischer, F. \(2011\). Computer-supported collaborative inquiry learning and classroom scripts: Effects on help-seeking processes and learning outcomes. *Learning and Instruction*, 21\(2\), 257-266.](#)

- [22] [de Jong, T., & van Joolingen, W. R. \(1998\). Scientific discovery learning with computer simulations of conceptual domains. *Review of Educational Research*, 68, 179-201.](#)
- [23] [Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A., Kamp, E. T., & ... Tsourlidaki, E. \(2015\). Review: Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review*, 14, 47-61.](#)
- [24] [Mäeots, M., Pedaste, M., & Sarapuu, T. \(2011\). *Interactions between inquiry processes in a web-based learning environment*. In Proceedings of the 2011 11th IEEE International Conference on Advanced Learning Technologies: 11th IEEE International Conference on Advanced Learning Technologies \(pp. 331-335\). Athens, Georgia, USA.](#)
- [25] [Quintana, C., Zhang, M., & Krajcik, J. \(2005\). A framework for supporting metacognitive aspects of online inquiry through software-based scaffolding. *Educational Psychologist*, 40, 235-244.](#)