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Online Eye-Tracking: Observing the Attention of Pre-service Chemistry Teacher from Non-Science Backgrounds in Solving Chemistry Problems

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ABSTRACT

This research uses online eye tracking techniques via an online research platform with webcam eye-tracking called RealEye. These techniques and platforms are used to observe the attention of pre-service chemistry teacher with non-science background in the Chemistry Study Program at UIN Antasari Banjarmasin while solving given chemistry problems. Two pre-service chemistry teachers from non-science backgrounds at high school level participated in a problem-solving task and then observed their eye movements which were an indication of the researchers observing participants' attention during problem solving. Attention can move quickly from one thing to another, so that attention can be discussed as an open orientation where selective action is taken on something by moving the eyes to that point, and a hidden orientation which is able to shift focus mentally without moving the eyes. The research uses descriptive analysis to obtain pre-service chemistry teachers' attention profiles during chemistry problem solving. The results of the research show that pre-service chemistry teachers with non-science background at high school level tend to take longer to observe, read and solve chemistry problems. The results obtained are also in line with the chemical problem-solving categories obtained by them, namely in the medium and low categories

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INTRODUCTION

Understanding how students from non-science backgrounds approach and solve chemistry problems is critical to developing effective teaching strategies, especially in classes that include non-science students. Conventional methods of assessing learning often rely on self-reported data or limited

behavioral observations, which may not fully capture the cognitive processes involved.

The eye tracking method with its current technology is one of the methods for observing students' visual attention and eye movements, providing a deeper understanding of the problem-solving strategies used, and can even

be used to determine students' metacognitive skills[1].

Eye tracking has been widely used in research in various fields of knowledge, and, in recent years, eye tracking has received attention in science teaching and chemistry education, as evidenced by studies[2], [3], [4], [5], [6], [7], [8]. For example, an eye-tracking study showed that eye movement data could reveal students' deficits in using the periodic table to solve problems [9], in addition eye tracking can be an influential tool in the analysis of representation levels in chemistry education [10].

Eye tracking involves measuring where and how long students focus their attention on various elements of a given problem, be it an equation, image, or text. This eye tracking method can reveal insights into cognitive load, reading comprehension, and decision making processes[11]. By analyzing data obtained from eye tracking, researchers who are also educators can identify patterns and areas where students may be experiencing difficulties, allowing for interventions to improve learning outcomes. It also allows for the acquisition of factors that influence students' attention in solving chemistry problems.

One of the tools that can be used to determine students' attention in solving chemical problems is an eye tracker (gazer recorder). Along with its development, eye trackers are now also available online. Eye trackers in online form are in the form of webcam eye-tracking, one of the research platforms using eye tracking is RealEye,

RealEye (www.realeye.io) is an online platform that facilitates webcam-based eye-tracking research. It enables marketers, educators, and UX designers to collect insights into participants' visual behavior using standard desktops, laptops, or mobile devices[12]. Approximately 43 published articles have used RealEye as a research instrument (can be seen on the RealEye website).

This study aims to utilize online eye-tracking techniques to observe the attention of pre-service chemistry teachers from non-science background as they solve chemistry problems. The use of sophisticated eye-tracking software and hardware will allow researchers to collect detailed data on fixation durations, thereby providing a comprehensive profile of students' visual attention. This information can be used to develop more effective teaching materials and teaching methods that meet the unique challenges faced by pre-service teachers from non-science backgrounds.

By leveraging the power of eye tracking technology, this study seeks to improve our understanding of how students from different educational backgrounds engage with complex scientific content, ultimately contributing to more inclusive and supportive learning environments. The findings of this study are expected to have significant implications for educational policy and practice, helping to bridge the gap between science education and the broader educational context. It also provides a reference for one of the webcam eye tracking applications that can be used to determine student attention, namely RealEye.

METHOD

The research method used for the problems raised in this study is a descriptive method. This method is used to obtain the attention profile of pre-service chemistry teachers who come from non-science backgrounds (majors) in their high school when solving chemistry problems. Pre-service chemistry teachers' attention is observed using online eye tracking techniques through an online research platform using an eye-tracking webcam called RealEye (<https://www.realeye.io/>).

The sampling technique (respondents/participants) of the study used purposive sampling. The respondents in this study were 2 female pre-service chemistry teachers from the Chemistry Education Study Program who had a non-science background (major) during high school but chose to study at the Chemistry Education Study Program at UIN Antasari Banjarmasin. Respondents at the time of data collection were in semesters 4 and 6. Although they were at different semester levels, the similarity between the two respondents was that they had taken basic chemistry and advanced basic chemistry courses, so the researcher assumed they had the same basic knowledge of chemistry, in addition to the similarity of background (major) during high school, namely social studies or social major. The age range of the respondents was also not much different, which was only 1 year gap.

The instruments used in the research were (1) an online research platform using webcam

eye-tracking (RealEye); (2) computer devices; (3) chemistry problem-solving questions consisting of 2 main questions with 6 sub-questions each arranged according to the problem-solving steps; (4) interview guidelines.

Pre-service chemistry teachers' attention during problem solving was measured using the eye tracking observation technique (read main) using the RealEye application. The data obtained were in the form of eye movement recordings in the form of gaze points (complete with fixation and fixation plots), as well as data in csv format containing participant quality grade, participant quality grade item, test item display order, exposure number, fixation point x, fixation point y, fixation starts at ms, fixation ends at ms, fixation ends at ms, fixation duration ms, saccade amplitude percent. The behaviors observed included eye movements, eye gaze direction and body posture [13]. Other factors that influence students' attention in problem solving were obtained through interviews.

Control factors carried out before collecting research data, so as not to cause unwanted responses, namely: (1) ready to take the test, (2) physically and mentally healthy (and have had breakfast before data collection), (3) conducive environment, (4) room lighting in good condition, (5) no people passing by, (6) position of computer screen, mouse and keyboard easy to access, (7) sitting position, head position and viewing distance from the screen as comfortable as the respondent feels (and in accordance with the position during the initial calibration of the RealEye eye-tracking webcam).

Data analysis using quantitative and qualitative descriptive [14]. Quantitative descriptive analysis using fixation duration data because the re-researcher did not set the AOI, so the export data (csv) from RealEye obtained is fixation data for the entire display (the entire area) not AOI fixation. Then the number of fixations or fixation count is seen from the number of rows of fixation data that appear in the fixation data excel. In addition, it is also supported by data on the value of the results of solving chemical problems.

Qualitative descriptive analysis using eye movement recordings from RealEye, problem-solving processes and answers, and student interview results.. The data obtained were combined with quantitative data[14]

RESULT AND DISCUSSION

The research data obtained regarding the attention of pre-service chemistry teacher with non-science background in solving chemical problems are summarized in Table 1 below.

Table 1.Eye Tracking Fixation Data, Results and Chemistry Problem Solving Categories

Data	Respondent 1			Respondent 2		
	Q1	Q2	Q1&2	Q1	Q2	Q1&2
Problem Solving Score	15	18	33	2	5	7
Problem Solving Values	36	43	79	5	12	17
Problem Solving Category			Medium			Low
Participant Quality Grade	3	4	3.5	4	4	4
Number of Fixation	9949	1066	2061024	1398	15275	2926466
Duration (ms)	09	115		918	48	
Average Fixation Duration (ms)	313.	281.	296.34	326.	344.04	335.6038991
	5546	89		85		
Fixation Count	3173	3782	6955	4280	4440	8720

Description of the attention of pre-service chemistry teacher with non-science background (majors) in solving chemical problems using online eye-tracking, can be explained based on the data presented in Table 1 and several previous related studies.

1. Problem Solving Scores and Values

The problem-solving scores and values obtained by respondent 1 on each problem-solving question were better than those of respondent 2. Likewise, when the combined

data for questions 1 and 2 (Q1 & Q2) were significantly higher than those of respondent 2, it showed that individually respondent 1 had better problem-solving abilities than respondent 2.

2. Problem Solving Categories

Respondent 1's problem-solving ability category is in the medium category and respondent 2 is in the low category.

3. Participant Quality Grade

Participant quality grade from both respondents respectively are at levels 3.5 and 4 which means Good. Good are great quality results, ready to analyze[15].

4. Fixation Duration and Count

Fixation duration and fixation count data show that each respondent spent a lot of time to observe (read and understand) and solve chemistry problems. Usually, the higher the number of fixation duration and fixation count, the more successful a person is in solving the problem, and this increase in the number of fixation duration and fixation count does not occur in problem solvers who fail[16]. The results of Türkoğlu's (2024) research also showed that students who spent more time reading questions and had a high number of fixations in the question reading area at the understanding stage also made students get high scores in problem solving [14]. These results are also in accordance with the research of Sajka and Rosiek [17] and Dobias et al [18] which states that long duration and high number of fixations generally contribute to success.

However, the research results obtained by the researcher showed deviations in respondent 2, where the high fixation duration and fixation count were not in line with success

in solving chemical problems. Respondent 2, as is known, obtained a score of 17 (low category) in solving chemical problems. Based on the deviations in the results, as suggested by Chettaoui et al.[19] in his research stated that it is necessary to combine eye tracking with learning traces and respondent behavioral attributes, in order to support accurate predictions of student learning performance in this case including problem solving.

Researchers in describing the attention of pre-service chemistry teacher with non-science background in solving chemical problems, researchers also juxtapose quantitative data with qualitative data from the results of eye tracking recordings in the form of gaze points and from the results of respondents/participants interviews. Although previous research states that fixation duration has been used for the study of a person's cognition and attention [20] However, describing attention based only on fixation duration and fixation count data can be problematic. This is especially true in complex studies [20]. The eye tracking recording display during problem solving Q1 and Q2 by each respondent can be seen in Figure 1 and Figure 2.



Fig. 1. Eye tracking recording in gaze point form for respondent 1 during chemistry problem solving (Q1: left and Q2: right)

In figure 1, respondent 1's attention is seen on the question narrative (longer) then continues to the sub-questions. The results of the interview with respondent 1 show that the respondent solves the problem by first looking for the problem, for example, there is data that is known in the narrative before solving the problem. Then after that, re-check whether the concept used is correct. When checking the answer to Q1, respondent 1 did not revise the answer because she did not understand the material. For Q2, respondent 1 felt more confident in answering it because she was more familiar with the material.

In figure 2, respondent 2's attention is seen to be longer on the sub-question section than the main narrative of the question, and seems to focus on the same point. Respondent

2 in her interview said that the problem-solving approach was by reading the narrative carefully first. However, because she was too focused on 1 question, she wasted time on the next question. Working on problem-solving questions like in this study was the first time, so the existing narrative must be fully understood. In addition, working with a computer connected to the online eye tracking application, namely RealEye, also requires mastery of the use of the keyboard so that there is no frequent calibration due to changing body and eye positions. Respondent 2 stated that the experience gained from working on this question needs to improve understanding in working on the question, besides that a lot of additional data is needed to solve the problem.



Fig. 2. Eye tracking recording in gaze point form for respondent 2 during chemistry problem solving (Q1: left and Q2: right)

Researchers can state that although pre-service chemistry teachers' attention in problem solving can be described from the results of eye tracking using online eye-tracking in this case RealEye with data presentation in the form of fixation duration and fixation count as well as gaze point recordings, we cannot ignore several factors that can also affect attention and of course fixation duration during problem solving including chemistry problem solving. Some of these factors are: problem complexity [16], elements of the problem [21], cognitive load [20], skill [20], confusion and interest in problem solving [20], as well as affective processes [20]

Researchers can also state that during chemistry problem solving, pre-service chemistry teacher from non-science

backgrounds face several challenges, including: having misconceptions and alternative conceptions [22], the complexity of chemical matter [23], lack or even no basic knowledge [22], attention and focus [24], negative perceptions and concerns about chemical materials [23].

By understanding the attention of pre-service chemistry teacher with non-science background when solving chemical problems, as well as knowing and understanding the challenges they face while solving chemical problems, teachers are expected to be able to develop effective strategies to support pre-service chemistry teacher with non-science background in learning chemistry. So that the problem-solving abilities of pre-service chemistry teacher with non-science

background increase or become better in solving chemical problems.

CONCLUSION

Based on the results of the study, it can be concluded that pre-service chemistry teachers of the Chemistry Education study program at UIN Antasari Banjarmasin with a non-science background during high school need more time when observing, reading and solving chemistry problems. This can be seen from the fixation duration and fixation count of each respondent.

Both pre-service chemistry teachers also seemed to focus more on the narrative of the question and its sub-questions (seen through the RealEye recording). Although the focus of attention was on the narrative of the question and its sub-questions and there was a high number of fixation duration and fixation count, the pre-service chemistry teachers stated (through interviews) that they were not too sure about the answers given due to the knowledge they had and the influence of the RealEye application used during problem solving. This statement was confirmed by the results of the problem solving obtained, which were in the medium and low categories.

Based on the research results and the limitations in the research conducted, the researcher suggests that in further research (1) compare the results between pre-service chemistry teachers with non-science background and pre-service chemistry teachers with science backgrounds in solving chemical problems. So that it can provide a clearer picture of the results of eye tracking for

pre-service chemistry teachers attention in solving chemical problems. (2) Consider and use online eye tracking applications other than RealEye that can be used in eye tracking, thereby increasing the variety of research tools. (3) Make the AOI (Area of Interest) of the problem solving carried out more specific, so that the attention data obtained becomes more complete (detailed) for each step of the problem solving carried out.

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Article Error You may need to use an article before this word.



Missing ", " You may need to place a comma after this word.



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Article Error You may need to remove this article.



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Run-on This sentence may be a run-on sentence. Proofread it to see if it contains too many independent clauses or contains independent clauses that have been combined without conjunctions or punctuation. Look at the "Writer's Handbook" for advice about correcting run-on sentences.



Hyph. You may need to add a hyphen between these two words.



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Proofread This part of the sentence contains a grammatical error or misspelled word that makes your meaning unclear.



Article Error You may need to use an article before this word.



P/V You have used the passive voice in this sentence. Depending upon what you wish to emphasize in the sentence, you may want to revise it using the active voice.



Article Error You may need to use an article before this word.



S/V This subject and verb may not agree. Proofread the sentence to make sure the subject agrees with the verb.



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Proper Noun If this word is a proper noun, you need to capitalize it.



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Article Error You may need to use an article before this word.



Missing ", " You may need to place a comma after this word.



Article Error You may need to use an article before this word.



Article Error You may need to use an article before this word. Consider using the article **a**.



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Proper Noun If this word is a proper noun, you need to capitalize it.



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Confused You have used **affect** in this sentence. You may need to use **effect** instead.



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