Relation Between Pre-Service Chemistry Teachers’ Science Literacy Levels And Their Some Scientific Process Skills

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Abstract

The purpose of this study is to determine the relationship between science literacy levels and some mental process skills of chemistry teaching undergraduates and to evaluate efficiency and mono and multi interaction of some chosen basic and causal mental processes. 6 open-ended questions covering different chemistry subjects and a semi-structured interview including 3 sub-questions relevant to those questions and that search efficiency of mental process have been prepared considering readiness level of the sample in order to determine efficiency of mental processes such as prediction, identifying variables, data collection and inference. The study sampling included 20 students chosen with random sampling method among the pre-service chemistry teachers studying at Ataturk University. From the interview results, there have been determined 97.2\% efficiency level from the questions for determining prediction skill; 67.6\% efficiency level from the questions for determining identifying variable process skill; 75\% efficiency level from the questions for determining data collection and 80.6\% efficiency level from the questions for determining inference skill. According to this, the prediction mental process skill’s having fairly higher efficiency level have mutually reinforcing mental process abilities of all active users a result of the like are not displayed, whereas, it can be said what a high level the front shorthand based on repeated experience present is. Consequently, there has been concluded that science literacy levels of the students in the sample is not high enough in terms of chosen and analyzed mental process skills.

Keywords: Scientific process skills; the causal mental process; pre-service teacher qualifications; science literacy

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1. Introduction

In general definition, science literacy is a combination of skill, attitude value, understanding and knowledge about science necessary for individuals to develop their research-investigation, problem solving and decision-making skills, to become life-long learning individuals, to maintain their worry about the world around them (Kavak, & TUFAN, 2006). Definition of science literacy just corresponds with active use of scientific process skills. Students’ acquiring problem solving skill is very important. Within this context, active ability to use prediction, data collection and inference steps of causal mental processes will make students closer to success. Scientific process skills have been categorized as basic processes, causal processes and experimental processes. Basic processes have been categorized as observation, quantifying, categorization, data recording, time and space relation; causal processes as predicting, identifying variables, data interpretation, inference; and experimental processes as hypothesizing, data use, setting a model, experimenting, control, and decision making. Causal processes are the query step of integrated processes. Data collection and interpretation step has been the one a student should be the most active individually. Because the student will diverge to research on this step. This situation is highly important for today’s educational system (DONMEZ, & AZIZOGLU, 2010; TEMIZ, 2001; SAAHUSEYINOGLU, & AKKOYUNLU, 2010). Doing research is a power that encourages learning desire of students. Students direct their own learning by themselves in this process. And the one that starts this process is curiosity and query. Students try to find an answer to the question they worry about, they collect data on relevant matter, they establish cause and effect relationship, they make inferences, they interpret and they also find not only one answer but the alternatives (SAAHUSEYINOGLU, & AKKOYUNLU, 2010). There has been determined that majority of the researches carried out on different learning fields and educational levels about scientific process skills have been for development and measurement of students’ scientific process skills (BASDAG, 2006; ISIK, 2008). Only there have not been encountered to a study for determining a specific process. Moreover, there have been studies that have been carried out to reveal the relationship between scientific process skills and books and programs (TEMIZ, 2001; BASDAG, 2006; KORAY, BAHADIR, & GECGIN, 2006). Students should benefit efficiently from data collection tools while solving a problem. The one who acquires this skill does not have difficulty in being science literate and developing causal mental processes. By this means, our country can make progress at science with the young who are aware of what they do and so the next generations will be able to be raised more consciously. Using mental process skills at a higher level will improve student to be more active retrieving them from being passive. Accordingly, on which extent students can use those skills should be determined and there should also be carried out studies about how the percentage of using those skills is increased.

In this study, there has been aimed to determine to what extent university students use causal mental processes, which is the sub-branch of scientific mental processes.

2. Method

The study is descriptive in terms of revealing causal mental process using level of students and relational in terms of analyzing the relationship between causal mental processes. For this reason, correlation and survey research models have been used together.

2.1. Sample

Sample selection has been made with analogous sampling method that takes place within the scope of purposeful sampling approach. Because there has been aimed to describe the use of causal mental processes, the participants were chosen attending the courses included the research subject that is, the prospective chemistry teachers who are attending at the department of chemistry education predicted the usage of the above process skills. The numbers of them are twenty students consisting of twelve boys and eight girls, respectively. The application was carried out in the spring term of 2011-2012 academic years.
2.2. Data Collection Tool

In this study, semi-structured interview has been used as the data collection tool. The interview prepared in accordance with expert opinions for examining causal mental processes defined as “prediction”, “identifying variables”, “data collection”, and “inference” has included totally 24 questions, 6 basic open-ended questions and 3 sub-questions for each basic question. There has been tried to determine “identifying variables”, “data collection” and “inference” skills within 6 basic open-ended questions. O’Sullivan suggested in his study that open-ended questions should be prepared within a general frame. Besides, he also mentioned that because semi-structured interview takes too much time it is normal to study with a few people and he shortly explained how semi-structured interview questions should be prepared. Semi-structured interview questions have been prepared benefiting from this study.

2.3. Data Analysis

The interviews conducted by the researcher have been recorded with a recorder within the knowledge of participants and then have been written down. So there has been aimed to avoid time and data loss. Absolute accuracy of the answers received by the participants has not been cared, to what extent mental process skills are used have been considered and accuracy percentages have been measured according to this. Percentages of acquired data have been measured and presented in tables. While preparing the table, total frequency and percentage values of each skill have been indicated. Moreover, frequency and percentage values of the answers have also been measured. Total skill percentages have been shown in column chart. And the correlation between the variables has been analyzed with SPSS analysis.

3. Result and Discussions

Findings relevant to data acquired from open-ended questions applied in the research have been taken place in this section. “Prediction” step has been tried to be determined within 6 basic questions (BQ). “Identifying variables”, “data collection”, “inference” steps have been tried to be determined respectively with the sub-questions given below.

1. What are the factors (other factors) for the actualization of this situation?
2. What do you to become certain from your assumption? (From which other data collection tools do you benefit from?)
3. From which aspect do the data you collected help you on this subject?

Basic question 1: How do you explain the situation of not observing the turning point while titrating benefiting from your old experiences?

Whereas there has been determined that whole of the participants have had a prediction about this question, majority of them, as 65%, have considered that a turning point could not be observed because of using a false indicator. 10% participants whose views have not been mentioned in Table 1 have emphasized that the turning point could not be observed because of the reasons as “matters’ impurity” and “false use of burette”. One participant mentioned that “The equivalence point has not been reached yet and neutralization has not occurred exactly”. “Data collection” stands out as the least used causal mental skill about this question. 40% part of 5 participants mentioned that “they will collect data through experimenting”. Another participant deduced in his statement that “My researches about this question will be helpful for me if I do a master degree in the future”. One another participant has stated that “The data I collected helps me to come to a conclusion and to notice a mistake I have made”. 
Table 1. Analysis of the question of “How do you explain the situation of not observing the turning point while titrating benefiting from your old experiences?”

| Prediction                          | Identifying Variable                          | Data Collection | Inference                          |
|-------------------------------------|-----------------------------------------------|-----------------|------------------------------------|
| N=20 (%100)                         | N=16 (%80)                                    | N=5 (%25)       | N=15 (%75)                         |
| False indicator has been used.      | There is impurity in used acid-base.          | I review the literature. |
| N=13 (%65)                          | N=11 (%68)                                    | N=4 (%80)       | I come to a correct conclusion.    |
| There is no exact neutralization.   | False indicator has been used.                | I look up to the book.   |
| N=3 (%15)                           | N=6 (%37)                                     | N=2 (%40)       | It will be beneficial in my future life. |
| Indicator was not used.             | There is no exact neutralization.             | I look up on the Internet. |
| N=2 (%10)                           | N=5 (%31)                                     | N=2 (%40)       | I become more careful in the following experiment. |
| Other                               | Other                                          | Other           | N=4 (%26)                          |
| N=2 (%10)                           | N=14 (%87)                                    | N=2 (%40)       | N=1 (%6)                           |

Basic Question 2: In your opinion, why is the serum that should be transparent in yellow color while you are carrying out the experiment of obtaining serum from the blood?

It can be seen in the table that the skill of prediction about this question has been used by whole participants. The majority of the participants have agreed that this situation has arisen from a color pigment in the blood or redundancy of the lipid rate in the blood. The other 35% have predicted that this situation has been arisen from incorrect hydro-extraction; blood’s containing protein and impurity in the blood. One participant has predicted about this question that “There can be a problem during hydro-extraction or a pathological problem can exist in person”. The other variables asserted on identifying the variable step are lipoidosis on the body of a person, having an illness or excessive fat burning on the body. One participant mentioned on data collection step that “S/he will benefit from the studies carried out on this subject” and “S/he will benefit more from the Internet”. Another participant has expressed that “I confirm it from the sources I trust in the correctness or I ask to lecturers”. A participant has mentioned on inference step that “If it is precursor of an illness, I firstly determine it and after doing research I become learned the reason of problem”.

Table 2. Analysis of the question of “In your opinion, why the serum that should be transparent is in yellow color while you are carrying out the experiment of obtaining serum from the blood?”

| Prediction                          | Identifying Variable                          | Data Collection | Inference                          |
|-------------------------------------|-----------------------------------------------|-----------------|------------------------------------|
| N=20 (%100)                         | N=14 (%70)                                    | N=13 (%65)      | N=16 (%80)                         |
| It has arisen from a color pigment in the blood.  | It can be arisen from the blood components. |
| N=5 (%25)                           | N=6 (%43)                                     | I review the literature. N=9 (%69) |
| It has arisen from blood’s having lipid. | There is impurity in blood.                   | N=4 (%29)       | I can explain the reason.          |
| N=5 (%25)                           | N=4 (%29)                                     | I look up to the Internet.   |
| It can arise from the person’s being ill. | It can arise from external factors.          | N=5 (%36)       | N=5 (%38)                          |
| N=3 (%15)                           | N=3 (%21)                                     | N=3 (%19)       | N=3 (%19)                          |
| Other                               | Other                                          | Other           | Other                              |
| N=7 (%35)                           | N=5 (%36)                                     | N=5 (%38)       | N=5 (%38)                          |

Basic question 3: What can be the problem if the cakes you have always fondly made do not rise this time?

Whole participants have predicted on prediction step. Majority of the participants have inferred that if there occurs a problem in rising, the baking powders should be spoiled considering that the baking powder is more efficient upon the rising of the cake. Other 30% participants have propounded that the whipping rate is slow, there is a problem on the ingredients and carbon dioxide gas outlet does not occur as homogenous. A participant on identifying variable step has expressed that “I can be added baking powder in a small amount or I can be added the egg little”. Another participant has listed the variables as “The baking powder or baking soda can be added inadequately. If there has been used wire whip instead of blender, there cannot occur a homogenous blending or
there can also be a problem that has arisen from the oven”. It has been noticed in the table that the least used causal mental process about this question is “data collection”. In general, participants have mentioned that “They will bake the cake again and again until they obtain a risen cake”. Apart from that, 100% part of the 5 participants giving positive answer to the question of “What do you do to be sure from this assumption?” has mentioned that “I ask to my mother.” Only one participant said that s/he will benefit from cookbooks. One participant has stated his/her thought on inference step that “I become more careful while making the following cake. I obtain a more delicious and risen cake”.

### Table 3. Analysis of the question of “What can be the problem if the cake you have always fondly made do not rise this time?”

| Prediction | Identifying Variable | Data Collection | Inference |
|------------|----------------------|----------------|-----------|
| N=20 (100%) | Oven temperature can be inappropriate. N=7 (47) | I ask to an expert. N=5 (100) | It provides me to make the cake correctly. N=5 (42) |
| N=7 (35%) | The baking powder can be spoiled. N=5 (25) | I look up on the Internet. N=2 (40) | I become more careful for the next time I make cake. N=4 (33) |
| N=6 (40%) | The ingredients can be added as missing. N=5 (25) | I look up the cookbook. N=1 (20) | I understood why it did not rise. N=2 (17) |
| N=6 (30%) | The baking powder can be added little. N=5 (25) | Other | Other |
| Other | Other | Other | Other |

### Basic question 4: What is the reason for peeled potato not to turn into black in water?

As it can be seen in the table above, on prediction step participants have two common views as “There occurs no blackening because water decreases polyphenol oxidase enzyme activity” and “There occurs no blackening because water drifts the contact with air away”. It has been noticed that the least used causal mental process about this question is identifying the variable. When other variables have been required from the participants about this subject, there has been received an answer as “I do not think any more ideas”. Whereas 43% part of 14 participants on data collection step said they benefit from the Internet, another 43% has emphasized that they will ask for help from lecturers have knowledge on this subject. In this question, data collection mental process use percentage of the participants is fairly higher than the other questions. This can be arisen from participants’ worrying about the answer of this question without determining a variable. This sense of wonder may encourage them to do research. The general view about what the data collected about this subject will serve is as “It makes me informed”. One participant has mentioned that “I consider that I should not keep potato out in a peeled way”.

### Table 4. The analysis of the question of “What is the reason for peeled potato not to turn into black in water?”

| Prediction | Identifying Variable | Data Collection | Inference |
|------------|----------------------|----------------|-----------|
| N=18 (90%) | Water decreases polyphenol oxidase enzyme activity. N=9 (50) | Water drifts the contact with air away. N=1 (100) | I get informed. N=7 (54) |
| N=1 (5%) | Water decreases the contact with air. N=8 (44) | I look up on the Internet. N=6 (43) | It helps me in the future. N=3 (23) |
| Other | It prevents potato from oxidation. N=1 (5) | I do research. N=5 (36) | I don’t keep the potato as peeled. N=2 (15) |
| N=0 (0%) | Other | Other | Other |

### Basic question 5: How can we prevent cars from overheating in the summer?

When Table 5 has been analyzed, 29% of the 17 participants who have used prediction mental process correctly have such an opinion that “We should add cold water to the engine in order to prevent cars from being overheated”. 18% has assumed that “The engine should not be overdriven”. Other 18% included the views as “The radiator
should be controlled” and “The thermostat should be changed”. It has been noticed that lesser used process than the others on this subject is “identifying variable”. Other 43% view under identifying the variable title in the table is “There should be added antifreeze” and “The car should be serviced regularly”. 33% on data collection step have considered that “I receive support taking the car to the mechanic”. When inference step has been dealt, the common view is “The data that I have helps me in order not to have a breakdown” and “Thanks to knowledge that I have I become more careful while driving”.

| Prediction                               | Identifying Variable          | Data Collection                      | Inference                                      |
|-------------------------------------------|-------------------------------|--------------------------------------|------------------------------------------------|
| N=17 (%85)                                | N=7 (%35)                     | N=9 (%45)                            | N=15 (%75)                                    |
| We can use cold water.                    | We cool the engine with water.| I ask to an expert.                 | I become more careful while driving.           |
| N=5 (%29)                                 | N=5 (%71)                     | N=3 (%33)                            | N=4 (%27)                                     |
| We do not overdrive.                      | We do not often stop and start.| I do research.                      | I notice this so I do not have a breakdown on the road. |
| N=3 (%18)                                 | N=3 (%43)                     | N=2 (%22)                            | N=4 (%27)                                     |
| We add antifreeze.                        | We should not overdrive.      | I look up to driving books.          | I become solved the problem.                  |
| N=2 (%12)                                 | N=3 (%43)                     | N=2 (%22)                            | N=3 (%20)                                     |
| Other                                     | Other                         | Other                                | Other                                         |
| N=3 (%18)                                 | N=3 (%43)                     | N=0 (%0)                             | N=5 (%33)                                     |

Basic question 6: In your opinion, what is the reason for tree variations to change from one region to another?

As it has been stated in Table 6, there has been no participant who has prediction upon this question. 85% of twenty participants thought that the change of diversity of trees from region to region related to “Climate differs from region to region”. One participant answered as “This has various reasons. The most important one is climatic conditions”. Variable identifying percentage about this matter is higher than the other questions. 44% of the 18 participants who have had variable identifying skill has assumed “soil structure” as the reason, 44% assumed as “altitude”, 44% assumed as “rainfall regime”. The other 61% which has not been mentioned in the table has listed the variables as “temperature, angle of incidence of the sun, wind, gravitation and endurance of trees”. On data collection step, whereas 50% of 14 participants stated that “I benefit from geography books” 43% said that “I benefit from the Internet”. One participant asserted that “There should be benefited from the other sources because s/he do not the information on the Internet as reliable”. Majority of the ones within 43% other participants which has not been mentioned in the table said that “They prefer being informed by watching documentary on this subject”. On inference step, the majority have mentioned that the data related to this subject “will make them informed” and “will make them informed about which tree will grow on which area”.

| Prediction                               | Identifying Variable          | Data Collection                      | Inference                                      |
|-------------------------------------------|-------------------------------|--------------------------------------|------------------------------------------------|
| N=20 (%100)                               | N=18 (%90)                    | N=14 (%70)                           | N=17 (%85)                                    |
| It is about the climate.                  | It is about the soil structure. | I look up the books.                | I learn which tree grows on which area. N=7 (%41) |
| N=17 (%85)                                | N=8 (%44)                     | N=7 (%50)                            |                                                |
| It is about altitude.                     | It is about altitude.         | I look up on the Internet.           | I get informed on this subject.                |
| N=2 (%10)                                 | N=8 (%44)                     | N=6 (%43)                            | N=7 (%41)                                     |
| It is about the soil structure.           | It is about the rainfall regime. | I do research.                     | I come to a specific conclusion.               |
| N=2 (%10)                                 | N=8 (%44)                     | N=6 (%43)                            | N=2 (%12)                                     |
| Other                                     | Other                         | Other                                | Other                                         |
| N=1 (%5)                                  | N=11 (%61)                    | N=6 (%43)                            | N=1 (%6)                                      |

As it is seen in Table 7, it can be said that the participants are successful at prediction and inference processes; however, they are insufficient at using identifying variable and data collection processes.
Table 7. Percentages to use causal mental processes

| Variable     | Data Collection | Inference |
|--------------|----------------|-----------|
| Prediction   | 96%            | 82%       |
| Identifying  | 59%            | 50%       |

When Table 8 has been analyzed, between 95 percent confidence interval, there has been noticed a positive linear relationship between prediction mental process and identifying variable and inference processes ($p = 0.043$; and $p = 0.021$) expresses the relationship is significant respectively; $r = 0.456$ and $r = 0.513$ expresses the existence of mid-range relationship). Moreover, there can also be mentioned that there is a positive linear relationship between identifying variable mental process and data collection, and this relationship is fairly high ($p = 0.001 = \alpha = 0.001; r = 0.683$).

Table 8. Correlation analysis results

| Prediction | Identifying Variable | Data Collection | Inference |
|------------|----------------------|----------------|-----------|
| Prediction | 1                    | .456*          | 1         |
| Identifying Variable | .219          | .683**        | 1         |
| Data Collection | .360              | .281          | 1         |

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed)

Regression analysis has been performed upon the variables in order to analyze the effect of other processes upon inference mental process (Table 9).

Table 9. Model Summary

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|-------|---|----------|-------------------|----------------------------|
| 1     | .543* | .294    | .162              | 1.690                      |

a. Predictors: (Constant), data collection, prediction, identifying variable
b. Dependent Variable: inference

From the Model summary table, R square value in the column of the arguments in "predict", "Variable Setting" and "Data Collection" as the independent variable explained the variance of "Inference" of 29% announced in the case of as dependent variable.

Table 10. ANOVA results

| Model         | Sum of Squares | df | Mean Square | F   | p     |
|---------------|---------------|----|-------------|-----|-------|
| Regression    | 19.081        | 3  | 6.360       | 2.226 | .125* |
| Residual      | 45.719        | 16 | 2.857       |     |       |
| Total         | 64.800        | 19 |             |     |       |

a. Predictors: (Constant), data collection, prediction, determination of variable
b. Dependent Variable: inference

The value on significance column from ANOVA results in Table 10 ($p = 0.125$) has shown that the relationship among the aforementioned variables is statistically insignificant at $p > 0.05$ level.
4. Conclusions

In this study, there has been tried to determine to what extent university students have used causal mental processes which are the sub-category of scientific process skills. Majority of the participants as 96% who participated in the study have been determined to have prediction ability related to a problem they encounter. Preservice teachers can easily make interpretations when they encounter a problem. When the participants have been required to identify a variable related to the question, thinking of them has taken a little time and nearly 59% has succeeded this. This rate indicates that variable identification skill of the pre-service teachers should be improved.

Data collection step is the one in which participants have the most difficulty. The participants who do not converge to do research said that “they will only repeat until they carry out the right experiment”. The participants who prefer data collection at the rate of 50% gave positive answers for 60 times to 6 questions in terms of this skill. There has been determined that the participants who gave positive answers prefer to do research as using the Internet, literature review, researching from the books and asking to an expert, respectively. It is very sorrowful for university students to have little utilization desire from the library. For pre-service teachers to improve themselves as science literacy they should have critical thinking skill and they should improve their problem solving ability. For that purpose, university students should use data collection tools efficiently, increase the use of library, read plenty of books and learn to use the Internet for scientific purposes. Participants have been successful at the rate of 82% on inference step. In order to provide students develop in terms of science literacy, it is necessary to help them improve their causal mental processes. Accordingly, increasing the performance of the students to the highest level on “data collection” step can provide them to be improved in terms of problem solving, critical thinking, doing research and making decisions; namely, to be a science literate.

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