Measurement of critical thinking skills in project-based chemical analysis instrumentation experiments

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Abstract. The study aims to apply project-based learning through the application of laboratory quality to improve basic laboratory skills, instrumentation analysis skills, and critical thinking skills to solve problems. In the preliminary experiment, authentic assessment is used to measure the level of basic laboratory skills and instrumentation analysis skills. In project work with the application of laboratory quality procedures, authentic assessment is used to measure critical thinking skills. There are 99% who have a high and very high level of basic laboratory skills. The achievement level of instrumentation analysis skills with high and very high criteria for pH-meter instruments, conductometers, and spectrophotometers in sequence 94, 85, and 83%. Instrumentation analysis skills for UV-Vis spectrophotometers are the most difficult to master by students then followed by a conductometer, and a pH-meter. The project work design must implement laboratory quality procedures which include how to take samples, manufacture working solutions, prepare samples, make calibration curves, sample measurements, calculate and analyze data, and test validation methods. Method validation testing activities include linearity testing, LoD and LoQ calculations, precision and accuracy tests. There are 63% have a high level of critical thinking skills, and there are no very high criteria.

1. Introduction

Globalization has resulted in major changes in the field of education. Higher education is demanded to reform the education system improve the quality of its graduates according to 21st-century competence [1]. Competence of graduates in analytical chemistry from various universities is to accommodate the needs of the workforce by 21st-century competencies, namely high-level thinking skills in analytical chemistry, the ability to perform instrumentation analysis accurately.

The results of the final assignment review compiled by students from the Chemistry study program FMIPA UNNES for the 2017-2019 period found that there were students who did not understand the concepts and principles of instrumentation analysis. Instrumentation analysis skills are still low, and the data used has not yet been tested for accuracy. There is no validation testing of analytical methods used as a guarantee of the quality of measurement results. Efforts should be made to increase the competence of graduates from the Chemistry study program at FMIPA UNNES so that they are equal and can compete with graduates from other universities in the global era.

The scientific approach through the project-based learning model is widely applied in the learning of chemical analysis instrumentation experiments to develop graduate competencies [1–6]. The application of project-based learning models can provide authentic experiences for students in developing critical thinking skills in solving problems through collaboration and communication [7],
Utilizing an accredited laboratory simulation model to carry out instrumentation analysis to obtain valid measurement results [9]. Forensic science methods are used to increase student involvement in experiment activities [5]. The results obtained provide greater benefits and experience than traditional experiments, and students are more critical and competitive. Chemical analysis instrumentation experiment by utilizing direct environmental monitoring is used to see misconceptions in modern chemical instrumentation [10], as well as to practice instrumentation analysis skills accurately, and foster an attitude of motivation, collaboration, and communication [11].

Classical and instrumental analysis results will be valid if the analysis is carried out by following the principles of scientific work through the application of laboratory quality procedures. Testing the validation of analytical methods as the application of laboratory quality procedures that include tests of linearity ranges, detection limits, quantization limits, precision, and accuracy. Application of laboratory quality procedures needs to be trained for students so that instrumentation analysis skills, scientific work abilities can be improved. It is necessary to develop a chemical analysis instrumentation experiment model that is able to increase the competence of graduates through project-based learning with the application of laboratory quality procedures (PjBL-ALQP).

The aim of the PjBL-ALQP model is to improve basic laboratory skills, instrumentation analysis skills, and critical thinking skills to solve problems. The preliminary experiment is intended to introduce various instrumentation to students as well as to measure the level of basic laboratory skills and instrumentation analysis skills. Project work provides authentic experiences for students, develops a correct understanding of scientific processes, and critical thinking skills [8]. The PjBL-ALQP model starts with giving open-ended, complex problems, and is designed so that students work collaboratively. Early knowledge needs to be possessed by students to look for literature in solving problems, as well as critical thinking skills to make hypotheses, construct procedures, carry out procedures, conduct data analysis, and make conclusions based on information collected to solve problems [1], [5].

2. Methods
2.1 Data collecting instruments
This research is mixed-method research with a concurrent embedded design model. The implementation of the PjBL-ALQP model was carried out using a one-group pretest-posttest design in a class of 65 students. In the preliminary experiment, authentic assessment is used to measure the level of basic laboratory skills and instrumentation analysis skills. In project work, it is used to measure critical thinking skills. The study materials in the PjBL-ALQP model include analysis of well water quality, analysis of tap water quality, analysis of quality of kitchen salt, analysis of essential minerals in fruits/vegetables, and analysis of heavy metals in waste.

2.2 Data analysis
The final product of the study is the PjBL-ALQP model which has been proven to improve graduate competencies. Data analysis was used to determine the level of basic laboratory skills, instrumentation analysis skills, and critical thinking skills, and the effectiveness of applying the PjBL-ALQP model.

3. Results and discussion
Basic laboratory skills and instrumentation analysis skills can be built through the active role of students in the preliminary experiment [6]. The integration of the preliminary experiment with project work associated with the application of laboratory quality procedures, in addition to improving basic laboratory skills and instrumentation analysis skills can also improve critical thinking skills[1]. The PjBL-ALQP model can develop critical thinking skills through the ability to search the scientific literature, translate scientific articles, compile experimental steps, operate instrumentation to collect data, calculate and analyze data, validate methods, and draw conclusions[5], [9]. The design of the PjBL-ALQP model was carried out for 12 weeks as presented in Table 1.
Table 1. Example of the PjBL-ALQP schedule

| Meeting               | Experiments schedule                                      |
|-----------------------|------------------------------------------------------------|
| Preliminary experiments|                                                            |
| Week 1                | Making a working solution                                  |
| 2nd week              | Standardize work solutions                                 |
| 3rd week              | Determination of Ka acetic acid with a pH-meter             |
| 4th week              | Determination of [HCl] through conductometric titration    |
| 5th week              | Determination of Cu$^{2+}$ with UV-Vis spectrophotometer    |
| Project work          |                                                            |
| 6th week              | Lab project                                                |
| 7th week              | Lab project                                                |
| 8th week              | Lab project                                                |
| 9th week              | Lab project                                                |
| 10th week             | Project reporting                                          |
| 11th week             | Presentation                                               |
| 12th week             | Compilation of scientific articles                         |

The implementation of the PjBL-ALQP model is carried out in two stages, namely preliminary experiment and project work. A preliminary experiment is useful for training students in making working solutions, introducing various modern instrumentation, as well as for measuring basic laboratory skills and instrumentation analysis skills. Project work is used to measure critical thinking skills in solving problems through instrumentation analysis.

3.1 Implementation of the PjBL-ALQP to basic laboratory skills

The results of observations during the experiment obtained data as many as 64 students (99%) have a level of basic laboratory skills with high and very high criteria (Figure 1). Of the three achievement groups (top, middle, and bottom), the achievement level of basic laboratory skills did not differ significantly. Student activities in the preliminary experiment design include analyzing the needs of working solutions, preparing descriptions of how to make working solutions, as well as making working solutions and their standardization.

![Figure 1. The distribution achievement level of basic laboratory skills](image)

Students have no difficulty in analyzing the needs of work solutions. Students can recap the needs of working solutions properly. As many as 99% of students have good knowledge in describing how to make working solutions. There is a description of making a working solution that does not meet the standard work instructions due to several error factors. These errors include: calculation (9%), purity (18%), volume (6%), and molecular formula (32%). Calculation errors occur because students only memorize how to make working solutions without correct understanding. Errors due to purity factors occur because students consider the purity of chemicals in the laboratory always 100%. Volume errors occur because of using an unusual size measuring flask (eg, a size of 300 mL). The error due to the
molecular formula factor occurs because students are wrong in calculating the molecular formula from the solution made.

The level of difficulty experienced by students in making a description of working solutions increases sequentially starting from liquid raw material (monobasic), the solid raw material (monobasic), and solid raw material (polybasic). There were only 88% of students who were correct in making a description of making a solution of acetic acid and hydrochloric acid (liquid raw material for monobasic), 82% for sodium hydroxide solution (solid raw material for monobasic), and 68% for oxalic acid and sodium tetra boric acid (raw material solid polybasic). An error was observed in making a description of making a working solution from a monobasic liquid raw material due to calculation factors. Monobasic solid raw material due to calculation and purity factors. Polybasic solid raw material due to calculation and purity factors. Polybasic solid raw material due to calculation factors, purity, and molecular formula.

Student activities in the implementation of making working solutions and standardization run smoothly. Some student activities recorded during observations that are not by the standard work instructions are in the process of weighing, dissolving, thinning, and titrating. Considering an analytical balance in an open condition, a container that does not fit the function, and the process of adding or subtracting chemicals directly above the balance sheet pan. Indiscriminate stirring is a mistake in the process of dissolution and dilution, and titration using one hand. There are still students who are less skilled in operating basic laboratory equipment such as weighing, diluting, dissolving, and titrating [11]. The achievement level of basic laboratory performance from each achievement group is already high. Students from each achievement group have a good ability in making experiment reports. The observed shortcoming was only in making conclusions, that is, not mentioning the concentration of working solutions that had been made.

A thorough evaluation of the findings during the preliminary experiment is used as feedback at the end of the experiment activity. Feedback is needed so that it will not be repeated in the next experiment [1]. Through feedback, knowledge, and understanding of analytical chemistry concepts especially in the context of making work solutions and standardization can be improved, and errors in using basic laboratory equipment can be avoided.

3.2 Implementation of the PjBL-ALQP model for instrumentation analysis skills
After the activity of making the working solution, the verification practice is continued by determining the ionization constant (Ka) of acetic acid using a pH-meter, conducting acid-base titration, and determining the copper sulfate concentration using a UV-Vis spectrophotometer. An understanding of instrumentation components, analytical techniques, data analysis, conclusion drawing as the focus of observation [11].

![Figure 2. The distribution achievement level of instrumentation analysis skill](image)

There are 58 students (89%) who have high and very high criteria for instrumentation analysis skills (Figure 2). The achievement level of instrumentation analysis skills with high and very high criteria for pH-meter instruments, conductometers, and spectrophotometers in sequence 94, 85, and 83%. Of the three achievement groups (top, middle, and bottom), the level of instrumentation analysis skills was not significantly different. Instrumentation analysis skills for UV-Vis spectrophotometers are the most
difficult to master by students then followed by a conductometer, and a pH-meter. Data related to the level of instrument analysis skills presented in Figure 3.

![Figure 3. The achievement level of instrumentation analysis skills](image)

The information obtained from Table 3. shows that the instruments that were mostly mastered by students in the sequence were the pH-meter, conductometer, and spectrophotometer. This can be seen from the accumulated achievement level of instrumentation analysis skills with high and very high criteria in operating the highest pH-meter compared to a conductometer and spectrophotometer (94, 84, and 83%). The same order of instruments is easier for students to master. How it works to operate a UV-Vis spectrophotometer is more complicated than a pH-meter and a conductometer. This can be seen from the achievement level of instrumentation analysis skill with very high criteria in operating the highest pH-meter compared to a conductometer and spectrophotometer (43, 26, and 11%). There were 4 students (6%) who were not yet skilled in operating the pH-meter properly, and 10 students (15%) for the conductometer, and 11 students (17%) for the spectrophotometer.

Observations and assessments at the design, implementation, and reporting stages of project work are used to measure the achievement level of instrumentation analysis skills. The results of observations and assessments are presented in Table 2. In the practical design phase, there were no major errors. The error that was observed was due to the students being less thorough in planning the loan of tools for the experiment: cuvettes, volume pipettes, pro-pipets, test tube racks, and small-sized measuring flasks are not borrowed by students, even though the equipment is very necessary for practical work. The number of group members is too large to cause ineffective collaborative division of tasks. Preparation for an experiment is only carried out by some members of the group. In the experiment, the ideal number in one group is a maximum of 3 people [14].

| Assessment stage      | pH-meter | Conductometer | Spectrophotometer |
|-----------------------|----------|---------------|-------------------|
| Experiment design     | 75       | 80            | 66                |
| Experiment implementation | 84      | 82            | 80                |
| Experiment report     | 71       | 63            | 65                |

The results of observations of the implementation phase obtained the results that the ability to operate the pH-meter and conductometer is no different. Both instruments have the same shape, size, and method of operation, although they have different functions. The similarity between the pH-meter and the conductometer helps and facilitates students in operating. Different conditions occur at the lab reporting stage with a pH-meter compared to conductometric titration. From the assessment of the experiment, reports revealed that students had difficulty in making conductometry titration charts and data analysis.
The number of steps that must be taken to determine the concentration of acid in acid-base titration using the conductometric method as the main cause of errors in the reporting of the experiment.

The biggest mistake in an experiment in determining the concentration of copper sulfate with UV-Vis spectrophotometer is at the lab reporting stage. The number of steps that must be passed by students to calculate the concentration of copper sulfate as the main cause of errors in the reporting of the experiment. The sequence of steps to be taken includes making standard solutions with various concentrations, measuring the absorbance of standard solutions and samples, making calibration curves, determining the calibration curve equation, calculating the concentration of analytes in a sample using the calibration curve equation, and dilution factors. The same thing must be done to determine the concentration of the analyte in the sample using the standard addition method. Difficulties experienced by students in preparing experiment reports using a spectrophotometer especially in processing data and calculations have an impact on the level of achievement of instrument analysis skills with very high criteria [1], [11].

Direct experience operating the pH-meter instrument, conductometer, and UV-Vis spectrophotometer can increase students' understanding of the principles and practical operational ways of the instrument [15]. Through the feedback mechanism and supported by displaying photos of findings during the experiment is used as an evaluation of the implementation of the experiment. Through feedback, mistakes made by students during the experiment can be corrected and not repeated in project work. Feedback activities are very useful to correct mistakes made by students during the experiment and by the results of research conducted by Carvalho, et al. (2015) and Sharples (2019) because it can increase retention [16], [17]. By providing feedback, instrumentation analysis skills can be improved.

3.3 Implementation of the PjBL-ALQP model for critical thinking skills

By experiment material that has been compiled, then in project work can be observed critical thinking skills of students in completing a given project. There were only 41 students (63%) with high criteria and no very high criteria. There is a student who is in poor criteria (Figure 4). By experiment material that has been compiled, then in project work can be observed critical thinking skills of students in completing a given project. There were only 41 students (63%) with high criteria and no very high criteria. There is a student who is in poor criteria (Figure 4).

![Figure 4. The achievement level of critical thinking skills](image)

Following the syntax of project-based learning, which starts from giving open, complex problems, then collaboratively students make project designs, determine schedules, carry out projects, and end with product assessments. Project design begins with the preparation of problems related to collaborative discourse. The next step is to look for scientific literature related to the theme in the discourse. From scientific literature relating to themes in the discourse, individual students propose alternative methods of instrumentation analysis that can be applied to answer problems. Of the various alternative instrumentation analysis methods proposed, collaboratively discussed and decided on one of the instrumentation analysis methods used. The choice of instrumentation analysis method must pay
attention to the availability and condition of the instrument, as well as the availability of supporting chemicals in the laboratory [1], [5], [9], [11], [18], [19].

In accordance with the PjBL-ALQP model, the project work design must implement laboratory quality procedures including how to take samples, manufacture working solutions, prepare samples, make calibration curves, sample measurements, calculate and analyze data, and test validation methods. Method validation testing activities include linearity testing, LoD and LoQ calculations, precision and accuracy tests [9], [10], [15].

Critical thinking skills are measured using criteria consisting of five dimensions, namely the ability to 1) give a simple explanation, 2) provide an in-depth/advanced explanation, 3) make a decision/judge, 4) make a conclusion, and 5) make a strategic move [20], [21]. The criteria for critical thinking skills are very suitable when used in the experiment [20]. Further analysis of the achievement level of critical thinking skills in completing projects into each dimension of critical thinking is presented in Figure 5.

3.3.1. **Dimensions provide a simple explanation.** The fact is that the S-01 made a mistake at the comprehension stage, which is not quite right in writing what is asked in the problem. This is because S-01 is not careful in reading the information provided in the problem so S-01 makes a mistake in writing what is asked of the problem. Measured by looking at the systematic suitability of the project design and experimental objectives. The format of the project design has followed the rules. There are 2 out of 19 groups that have not included hypotheses and data analysis techniques in the project design. The reference used as the basis for preparing the project design is in the form of scientific articles, and only 2 groups are in the form of a standard method of SNI. The project design title is following criteria such as interesting, concise and appropriate to the problem, although there are still errors in making the project title. Project designs are still found with goals that are not concise, specific, and problem-specific. The project objectives did not mention the heavy metal to be measured, the source of the waste analyzed, and the mention of the extension of the AAS which was not appropriate. Mastery of the concept of spectroscopy is still lacking.

The lowest achievement occurred in the ability to form hypotheses. Most of the hypotheses made by students have not been connected between variables, and have not been measured. There is also a project design with no hypothesis. The achievement level of dimensions provides a simple explanation of 66%.

3.3.2. **Dimensions provide an in-depth explanation.** The dimension giving depth explanation is the lowest achievement compared to other dimensions. Measured by looking at the systematic foundation of the library, the relationship between concepts, the accuracy of the use of formulas. The ability of
students in making problem formulations is still low. A good problem statement must be made clearly, related to the topic in the discourse, and made in a question sentence. Besides, there are also project designs that do not have a problem statement. There are several groups in making project designs that only list one instrument without reasons. Through discussion, an instrumentation analysis method should be determined that is used in the project regarding the availability of instruments, instrument conditions, and the need for supporting chemicals.

The contents of the background in the project design are logically written according to the problems in the discourse and supported by references that have been obtained. Although students can determine alternative methods of instrumentation analysis that can be used to answer problems, there is still very little information provided regarding the principle of instrumentation measurement and the quantitative relationship between instrument responses and analytes concentrations. In the project design compiled by students, a table for observational data has been included as well as for classifying it, but only 2 groups have included ways of analyzing the data to be obtained.

3.3.3. Dimensions of making decisions / assessing. Assessed through the accuracy of the tool, the experimental material used, the steps of the experiment, the way data is collected. The equipment written in the project design was appropriate for its type and function, but the chemicals wrote were still incomplete. Language constraints are the cause of difficulties for students in making work methods. Difficulties in converting the contents of scientific articles into work steps. High accuracy and mastery of concepts are needed to be able to arrange good work steps. Through periodic guidance, the work steps can be arranged well.

Difficulties in making work solutions with a concentration of mg/L (ppm) were also experienced by students in designing projects. Difficulties in preparing work steps to test the precision and accuracy experienced by most groups. The group that draws referenced sources from SNI has no difficulty because the work steps for accuracy and precision testing have been included.

Students have no difficulty in using simple laboratory equipment to take solids, take liquid, dissolve, and dilute, and weigh. This can be understood because students have practiced verification practices. In operating instrumentation equipment there were also no obstacles because they had received information and training in verification practices and each instrument was equipped with work instructions as guidelines for operating.

3.3.4. Dimensions make conclusions. Judged based on the depth of data analysis, discussion, and conclusions. This achievement level is measured through the assessment of project reports related to the creation of working solutions, the creation of calibration curves, the results of the validation test methods covering linearity, LoD, LoQ, accuracy, and precision.

In making the working solution has been done correctly, although initially had difficulty in calculating the solution making with ppm concentration. The calculation and making of the calibration curve are correct, this can be understood because students have practiced in making calibration curves at the verification practice.

The calculation method to determine the amount of LoD and LoQ is correct, but the method of calculation to determine the precision and accuracy still needs intensive guidance from the lecturer. The results of the validation test of analytical methods which include linearity, LoD and LoQ tests, accuracy, and precision are still low. Calibration curves with $r^2 > 0.9$ are 68%, LoD and LoQ are relatively low 37%, precision is 21%, and high accuracy is only 26%. From this circumstance shows students still need to practice in determining the method validation testing.

3.3.5. Dimensions make strategic steps. The systematic and quality of the report's appearance is used as a reference to assess this dimension. The quality and systematics of project reports prepared by students are following existing guidelines. The lowest indicator is only in the appearance of reports that are less interesting, consistent, and discussion that is not deep enough. The discussion is arranged too superficially and only conveys the results without explanation of cause-effect or influence between variables. The format of the project report prepared by the students is following the guidelines used, the
shortcomings that are seen in the references are too minimal, scientific articles, books, or research reports with long published years.

From the analysis of critical thinking skills, it can be learned that in project work students are required to search literature through various sources to find instrumentation analysis techniques, so that it will require a person to think critically to be able to obtain, choose, and process the information effectively [19]. Through the scientific literature obtained can be used to make work steps in project design [1], increase understanding of the instruments used [15], and to carry out the development of analytical methods [5].

The good project design will produce objective truth if it is supported by a reliable analytical method so that the results of the analysis are guaranteed to be of good quality and produced valid data. The performance of the analytical method is evaluated by measuring linearity, LoD, LoQ, precision, and accuracy. Through assigning project design tasks to validate the analysis method, critical thinking skills of students develop.

The provision of problems that are open, complex and related to daily life that must be resolved can foster student interest in learning and can increase motivation [3], [11], [22]. Completion of projects related to daily life can help students hone critical thinking skills because students are required to interact directly with the real world collaboratively. Through discussion is an effective way to train and develop critical thinking skills, because in the discussion there is an exchange of opinions and in the process of exchange of opinions that students can consider, reject, or accept the opinions of themselves or others to match the opinions of the group. This is what ultimately fosters students' critical thinking skills [23].

The level of critical thinking skills is influenced by the ability of students to formulate hypotheses, formulate problems, look for the reference to standard methods, translate the contents of scientific articles into work steps, compile steps of validation test methods, difficulties in doing calculations and data analysis. The achievement level of the critical thinking skills of students can still be improved through training. Critical thinking skills are skills that can be trained through learning integrated verification of project work by providing open, complex problems related to daily life.

4. Conclusion
The PjBL-ALQP model developed has the characteristics of emphasizing basic laboratory skills, instrumentation analysis skills, and critical thinking skills. The achievement level of basic laboratory skills, instrumentation analysis skills, and critical thinking skills in the high and very high categories are 99, 89, and 63% respectively.

5. References
[1] Cavainato A G 2017 Anal. Bioanal. Chem. 409 (6) 1465
[2] Bagheri M, Ali W Z W, Chong M B A and Daud S M 2013 Contemp. Educ. Technol. 4 (1) 15
[3] Bowden J A, Nocito B A, Lowers R H, Guillette L J, Williams K R and Young V Y 2012 J. Chem. Educ. 89 1057
[4] Chun M S, Kang K I, Kim Y H M and Kim Y H M 2015 Univers. J. Educ. Res. 3 (11) 937
[5] Frederick K A 2013 Anal. Bioanal. Chem. 405 (17) 5623
[6] Lee J S, Blackwell S, Drake J and Moran K A 2014 Interdiscip. J. Probl. Learn. 8 (2) 18
[7] Jollands M, Jolly L, and Molyneaux T 2012 Eur. J. Eng. Educ. 37 (2) 143
[8] Wurdinger S and Qureshi M 2015 Innov. High. Educ. 40 (3) 279
[9] Taylor P D P, Baralkiewicz D, da Silva R B, Voncina D B, Bulska E, Camoes M F, Dobrowolski R, Elskens M, Leito I, Majcen N H, Mandjukov P, McCourt J, Randon J and Peramaki P. 2015 Anal. Bioanal. Chem. 407 (23) 6899
[10] Carbó A D, Adelantado V J G and Reig F B 2010 US-China Educ. Rev. 7 (7) 15
[11] Robinson J K 2013 Anal. Bioanal. Chem. 405 (1) 7
[12] Dalgarno B, Bishop A G, Adlong W and Bedgood D R 2009 Comput. Educ. 53 853
[13] Karataş 2016 Chem. Educ. Res. Pract. 17 (1) 100
[14] Santos D M D L, Montes A, Sánchez-Coronilla A and Navas J 2014 J. Chem. Educ. 91 (9) 1481
[15] Fakayode S O 2014 Anal. Bioanal. Chem. 406 (5) 1267
[16] Carvalho C, Fiuza E, Gama P and Salema M 2015 *J. Turkish Sci. Educ.* **12** (2) 21

[17] Sharples M 2019 *OEB Insights* 1

[18] Fakayode S O, King A G, Yakubu M, Mohammed A K and Pollard D A 2011 *J. Chem. Educ.* **89** 109

[19] Henderson D E 2010 *J. Chem. Educ.* **87** (4) 412

[20] Sarwi, and Liliasari 2010 *Forum Kependidikan*. **30** (1) 37

[21] Sarwi, Rusilowati A and Khanafiyah S 2012 *J. Pendidik. Fis. Indones. (Indonesian J. Phys. Educ.)* **8** (1) 41

[22] Smith O L and Dragojlovic V 2013 *J. Lab. Chem. Educ.* **1** (2) 25

[23] Arfianawati S, Sudarmin and Sumarni W 2016 *J. Pengajaran MIPA*. **21** (1) 46