Non-linear learning in online tutorial to enhance students’ knowledge on normal distribution application topic

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Abstract. This study aimed to analyze the enhancement of non-linear learning (NLL) in the online tutorial (OT) content to students’ knowledge of normal distribution application (KONDA). KONDA is a competence expected to be achieved after students studied the topic of normal distribution application in the course named Education Statistics. The analysis was performed by quasi-experiment study design. The subject of the study was divided into an experimental class that was given OT content in NLL model and a control class which was given OT content in conventional learning (CL) model. Data used in this study were the results of online objective tests to measure students’ statistical prior knowledge (SPK) and students’ pre- and post-test of KONDA. The statistical analysis test of a gain score of KONDA of students who had low and moderate SPK’s scores showed students’ KONDA who learn OT content with NLL model was better than students’ KONDA who learn OT content with CL model. Meanwhile, for students who had high SPK’s scores, the gain score of students who learn OT content with NLL model had relatively similar with the gain score of students who learn OT content with CL model. Based on those findings it could be concluded that the NLL model applied to OT content could enhance KONDA of students in low and moderate SPK’s levels. Extra and more challenging didactical situation was needed for students in high SPK’s level to achieve the significant gain score.

1. Introduction

Education Statistics is one course that must be taken by students in several study programs in Faculty of Teacher Training and Education Universitas Terbuka (UT). The course is to teach the concepts, procedures, and the use of statistical theory that the students must use in completion of their final program reports. One most important topic is normal distribution application. The normal distribution is a statistical distribution that relates to other statistical topics, especially in inference statistic. Kokoska [1] stated that “the bell shape density curve can be used to model many natural phenomena and the normal distribution is used extensively in statistical reference.” On the other side, Mulholland & Jones [2] stated: “the most sets of random errors follow the normal ... it has been shown that the results obtained by assuming a no normal population to be normally distributed are reasonably accurate.”

Preliminary study shows that there are 36% students per semester in who do not pass final exam of Education Statistics, students’ participation in online tutorial (OT) activities do not have significant influence on the achievement of the final exam, and the learning materials provided by tutors in OT activities are mostly in the pointers form packaged in PowerPoint presentations with learning process,
and which, therefore, are called “e-presentation” or “e-lectures” or “e-reading” [3]. In this study, the latter -shown diagrammatically below in Figure 1.a- is suspected as the main cause of the students’ participation in OT do not have many influences to the readiness of students in working out the final exam. Without further explanation in multi-media forms (more detail explanation, oral presentation, video presentation, etc.), students have difficulties in understanding such materials. It is this consideration that this study is designed i.e. each material presentation need further explanation, especially for those who inadequate statistical prior knowledge (SPK). Figure 1.b shows the design of learning material called Non-Linear Learning (NLL) Model (while that of figure 1.a.- in this study- is called Conventional Learning or CL Model).

![Figure 1.a. Flowchart of current design OT content in Education Statistics course](image)

![Figure 1.b. Flowchart of proposed design of OT content in Education Statistics course](image)

Based on such reasoning, it can be formulated the problems of this research as follow:

- Is there gain score differences of knowledge on normal distribution application (KONDA) between students that learn OT content in NLL model and students that learn OT content in CL model?
- Is there gain score difference of KONDA between students who had low, moderate, and high SPK’ scores after they learn OT content both in NLL and CL model?
- Is the student’s KONDA who learn OT content in NLL model better than those who learn OT content in CL model?

2. Literature Review

According to Meyers [4], non-linear learning is a form of learning that is organized in complex ways by involving the ongoing systems and the underlying norms and values in substantial manners. Overall approach and prerequisites needed to produce and interpret learning are expected to alter the creative process of self-organization. Chen [5] states that non-linear learning applied in a hypermedia program can provide learners with many opportunities to explore and discover learning material that appropriate to their own individual needs. Some learners who are uncertain of the importance of a series of explanations in non-linear learning programs will be disoriented so that their learning cannot achieve better results. Therefore, to develop OT content with NLL model that is oriented to ameliorating students learning obstacle, a tutor can use Didactical Design Research (DDR) developed by Suryadi [6].

The development of learning material using DDR may be performed through three stages. The first stage of DDR is developing a hypothetical didactical design which is oriented to solve students learning obstacle. This stage can be performed before OT content presented to students. The second stage of DDR is by performing metapedadidactical analyses that is performed in the learning process. Lastly, the third stage in DDR is retrospective analyses that is performed after learning process finished. In
developing the hypothetical didactical design, the tutor needs to perform didactical phenomenon observation in the previous semester. This observation is useful to know which topics that need to be emphasized in their OT content. It also helps the tutor to identify students’ learning obstacle. The next step in development hypothetical didactical design is to develop a didactical situation that can identify students’ comprehension level after they studied the printed learning material independently. The final step in the development of hypothetical didactical design is to develop several didactical-pedagogical anticipations which are expected to give students a better understanding of the given didactical situation.

To develop a didactical situation, an OT tutor can present a challenging problem for the students that are related to learning material which is presented by OT tutors. In the learning topic of normal distribution application, OT tutors need to stress concept, procedures, problem solution and statistical rules of normal distribution application. The problems of a didactical situation can be recognized from data in previous semester in the form of the students’ answer in their final exam, their response in OT discussion forum, and the result of students’ performance in working out of OT tasks. These three sources can be found from the database, the result of the final exam and OT log activity of the students. Besides, OT tutor can perform interview to the students who took the course in the previous semester to get further information about what the real problems are. The didactical situation can be differently responded by students. So, from an initial didactical situation can emerge new situation as a result of students’ varied response to the initial didactical situation. The new situations might be as many as or even more than that varied response. The more various learning activity setting, the more various new didactical situation will be. As a result, the learning process can be very complex.

Related to the complexity of the new didactical situation, didactical-pedagogical anticipation can be developed by OT tutor as scaffolding that will direct the students to understand and to solve the problems that may emerge in the didactical situation. The didactical-pedagogical anticipation can be related to other concepts related to normal distribution application topic. As a result, related didactical-pedagogical anticipation will create NLL. By using NLL in OT content, the tutor must realize the individual difference and they need to pay attention to NLL as a way to accommodate different learning preference in each student. One facility in UT’s OT application that can be used as NLL is “Lesson”. Lesson is one feature in UT’s OT application that offers the flexibility of website, interactive, quizzes while enabling the development of branched learning material [7]. By using Lesson, a student can have an opportunity to get the needed materials. In Lesson, a student can as well explore the consequences of their response. As an example of a hypothetical didactical design that covers the relationship between didactical situation and its anticipation is described in Figure 2 and Table 1 as follow.

![Figure 2. Flowchart of an example of hypothetical didactical design in OT content](image-url)
| Frame Code | Activities of Learning | Navigation |
|------------|-----------------------|------------|
| DS.1.0     | Given a case study containing mean and standard deviations values for large samples ($N > 100$) and normally distributed, students were asked to determine the area under the standard normal curve between the values $x_1 = \bar{x} = \mu$ and $x_2 > \bar{x}$ | If the student can determine the area properly then the student can access DS.2.0 However, if the student cannot determine the area properly then the student must access ADP.1.1 |
| ADP.1.1    | Provides an explanation of the procedure of determining area under the standard normal curve between $x_1 = \bar{x} = \mu$ and $x_2 > \bar{x}$ of the case studies which contained mean and standard deviation values for large samples ($N > 100$) and normally distributed | If the student has understood the explanation of ADP.1.1 the student can continue accessing DS.1.1 |
| DS.1.1     | Given a case study that contains the mean and standard deviation values for large sample ($N > 100$) and normally distributed, the student is required to determine the values of $z_1$ for $x_1 = \bar{x} = \mu$ and $z_2$ for $x_2 > \bar{x}$ | If the student can determine the $z_1$ and $z_2$ values correctly then the student can access DS.1.2 However, if the student cannot determine the $z_1$ and $z_2$ values correctly then the student must access ADP.1.2 |
| ADP.1.2    | Provides an explanation of the procedure of determining the values of $z_1$ for $x_1 = \bar{x} = \mu$ and $z_2$ for $x_2 > \bar{x}$ for the case study which contains the mean and standard deviation values for large samples ($N > 100$) and normally distributed | If the student has understood the explanation of ADP.1.2 the student can continue accessing DS.1.2 |
| DS.1.2     | Given a case study contains the mean, standard deviations, and the figure of area under the standard normal curve between the values $x_1 = \bar{x} = \mu$ and $x_2 > \bar{x}$ for large samples ($N > 100$) and normally distributed, students were asked to determine the area under the standard normal curve between the values $x_1 = \bar{x} = \mu$ and $x_2 > \bar{x}$ | If the student can draw the area under the standard normal curve between values of $z_1$ for $x_1 = \bar{x} = \mu$ and $z_2$ for $x_2 > \bar{x}$ correctly then the student can access DS.1.2. However, if the student cannot draw correctly then the student must access ADP.1.3 |
| ADP.1.3    | Provides an explanation of the procedure of drawing the area under the standard normal curve between values of $z_1$ for $x_1 = \bar{x} = \mu$ and $z_2$ for $x_2 > \bar{x}$ | If the student has understood the explanation of ADP.1.3 the student can continue accessing DS.1.3 |
| DS.1.3     | Given a case study containing mean, standard deviations, and the figure of area under the standard normal curve between the values $x_1 = \bar{x} = \mu$ and $x_2 > \bar{x}$ for large samples ($N > 100$) and normally distributed, students were asked to determine the area under the standard normal curve between the values $x_1 = \bar{x} = \mu$ and $x_2 > \bar{x}$ | If the student can determine the area properly then the student can access DS.2.0 However, if the student cannot determine the area properly then the student must access ADP.1.4 |
| ADP.1.4    | Provides an explanation of the procedure of determining area under the standard normal curve between $x_1 = \bar{x} = \mu$ and $x_2 > \bar{x}$ of the case studies which contained mean and standard deviations values for large samples ($N > 100$) and normally distributed | If the student has understood the explanation of ADP.1.4 the student can continue accessing DS.2.0 |

Table 1. Flowchart’ explanation on Figure 2
Based on Figure 1 and Table 1, initial didactical situation (DS.1.0) can be used as a tool to know the learning materials the students needed to understand the concept, procedures, problem-solving, and statistical rules related with normal distribution application topic. The initial didactical situation will mean a lot if the tutor provides instruction to learn the printed learning material independently before learning OT content. For students who already have adequate knowledge of the concept of area under the standard normal curve between negative z value till z = 0, they can continue for the next learning. While, for students that still have difficulties in understanding the concept, they need to learn the concept of area under standard normal curve through ADP.1.1 till ADP.1.4.

3. Methods
The design used in this study is quasi-experiment. The subject is divided into two groups. The first group is experimental class given OT content in the NLL model, while, the second group is the control class given OT content in the CL model. Population in this study is the students of Basic Education in Graduate program of UT. Purposive random sampling technique is used to choose the sample. According to Creswell [8], purposive random sampling is the main strategy in sampling technique that combines both quantitative and qualitative criteria. There are 85 students in the experimental group and another 85 students in control group. Instruments used are objective tests to measure the statistical prior knowledge (SPK) and the knowledge of normal distribution application (KONDA). Before using the whole instruments, all items of the objective test are field-tested first to ensure their content validity, face validity, construct validity, and item validity. Samples used in this field testing are 30 students of Basic Education in Graduate program of UT that registered in Education Statistics course in a previous semester. Based on the result of field tests, it can be concluded that all SPK and KONDA instruments are eligible to be used [9].

Data used in this study includes SPK score, pretest score of KONDA and posttest score of KONDA. Data are collected by the online objective test in UT’s OT application. Students are given enough time to finish all the questions of SPK and KONDA instruments. Data on the SPK and pretest of KONDA are collected before the students learn different OT content. Meanwhile, data of posttest about KONDA are collected after the students learn different OT content. The students are grouped in according to the score level of SPK before learning OT content. For the students whose SPK score is less than \( \bar{x} - s \), they will be grouped as low SPK, those whose SPK score between \( \bar{x} - s \) and \( \bar{x} + s \), are grouped in moderate SPK, and those whose SPK score more than \( \bar{x} + s \), they are grouped in high SPK. Meanwhile, for testing the enhancement, the normalized gain score (G) of students’ KONDA are used in statistical analysis. G is obtained by the following formula [10].

\[
G = \frac{\text{posttest scores} - \text{pretest scores}}{100 - \text{pretest score}}
\]

The preliminary statistical analysis is firstly conducted before data analyses. The analysis is on the normality of SPK score both for students in experimental class and control class to determine which statistical test of homogeneity that appropriate. The analysis also on normality test of a normalized gain score of KONDA both for students in experimental class and control class to determine which statistical test that is appropriate to show OT content influence on KONDA enhancement.

4. Findings and Discussion
It can be shown that students' SPK average score before they learn different OT content is 54.15 with standard deviation as 18.3. Based on the results, the students are categorized into three levels. Those who have SPK score less than 36.20 are in low SPK level, those who have SPK score between 36.20 and
and 72.82 are in moderate SPK level, while those who have SPK score more than 72.82 are in high SPK level. It can be also shown that average SPK score of the experimental class is 56.31 with standard deviation as 18.69, while those from control class is 52.71 with standard deviation as 17.75. Meanwhile, the Kolmogorov-Smirnov test statistic in Table 2 can be used to determine the homogeneity statistical test that appropriate.

Table 2. The summary of normality test for students’ SPK score

|         | Experimental | Control |
|---------|--------------|---------|
| N       | 85           | 85      |
| Test Statistic | 0.116       | 0.116   |
| Asymp. Sig. (2-tailed) | 0.007       | 0.007   |

Table 2 shows that the students’ SPK score in both classes is not normally distributed. Therefore, homogeneity statistical test for the students’ SPK score of both classes is performed by using Levene test statistic. The result of Levene test statistic shows the value 0.224 with Sig value as 0.637. This means that students’ SPK score in experimental and in control class are equal. Next, the result of normality test statistic using Kolmogorov-Smirnov testing of students’ KONDA gain score for students who learn OT content in NLL and CL models are presented in Table 3.

Table 3. The summary of normality test for students’ KONDA score

| OT Content Model | SPK Level | NLL | CL |
|------------------|-----------|-----|----|
| Test Statistic   |           | 85  | 85 |
| Asymp. Sig. (2-tailed) | 0.013   | 0.000 | 0.037 |

Table 3 shows that almost all statistical tests of the students’ KONDA gain score in each group are not normally distributed (only high SPK level is normally distributed). Meanwhile, the result of normality test of students’ KONDA gains score based on OT content models in each SPK level are presented in Table 4.

Table 4. The summary of normality test for students’ KONDA gain score based on OT content models in each SPK level

| OT Content Model | NLL | CL |
|------------------|-----|----|
| Test Statistic   |     |    |
| Asymp. Sig. (2-tailed) |     |    |

Table 4 shows that almost all of students’ KONDA gain score are normally distributed. Only two groups (moderate and low SPK level of students that learn OT content in CL models) are not normally distributed. Based on the normality test in Table 3 and 4 it can be concluded that the appropriate statistic to test the influence of different OT content models to students’ KONDA gain score in a different level of SPK is non-parametric test statistic. The appropriate non-parametric statistic to test the influence of two different models of OT content is the Mann-Whitney test statistics.

Table 5. The summary of influence test for difference OT content models to students’ KONDA score

| OT Content Model | N | Median | W | Z  | p-value |
|------------------|---|--------|---|----|---------|
| NLL              | 85| 0.2778 |   |    |         |
| CL               | 85| 0.0000 | 9193.0 | 0.3000 | 0.0000  |
Table 5 shows that there is a significantly different of KONDA gain score between the students that learn OT content in NLL model and in CL model. Next, appropriate non-parametric statistic to test the influence of three different SPK levels to students’ KONDA gain score is Kruskal-Wallis test statistic.

Table 6. The summary of influence test for difference SPK levels to students’ KONDAT score

| SPK Level | N  | Median | Z   | H     | p-value |
|-----------|----|--------|-----|-------|---------|
| Low       | 23 | 0.000  | -2.01 |     |     |
| Moderate  | 108| 0.125  | -0.51 | 8.05  | 0.018  |
| High      | 32 | 0.250  | 2.36  |       |         |

Table 6 shows that there is significantly different KONDA gain score among students in low, moderate and high SPK levels. Based on the results of Tables 5 and 6 the statistical testing can be continued to test the influence of differences OT content models in each SPK levels to gain score of students' KONDA. The non-parametric statistic to test the influence of interaction between OT content models and SPK levels to students’ KONDAT gain score is Kruskal-Wallis test statistic.

Table 7. The summary of influence test for interaction between OT content models on each level of SPK to student’s KONDAT improvement

| OT Content Model | SPK Level | N  | Median | Z   | H     | p-value |
|------------------|-----------|----|--------|-----|-------|---------|
| NLL              | Low       | 10 | 0.381  | 1.77|       |         |
|                  | Moderate  | 52 | 0.232  | 2.94|       |         |
|                  | High      | 23 | 0.500  | 3.59|       |         |
| CL               | Low       | 15 | -0.143 | -3.32| 42.60 | 0.000 |
|                  | Moderate  | 57 | 0.000  | -4.32|       |         |
|                  | High      | 13 | 0.167  | -0.06|       |         |

Table 7 shows that there is a significant difference of KONDA gain score between students in deferent SPK levels that learn different models of OT content. Based on the results in Table 5, Table 6 and Table 7 show that statistical testing can be continued to compare KONDA gain score between students that learn OT content in NLL model and in CL model. That testing not only compares the two models in general but also compare those in each SPK levels. Furthermore, based on the normality test in Table 3, a statistical testing that can be used to compare KONDA gain score between students that learn OT content in NLL model and in CL model is the Mann-Whitney test statistics.

Table 8. The summary of compare means test for students’ KONDA score between two models of OT content

| OT Content Model | N  | Median | W   | Z   | p-value | Conclusion |
|------------------|----|--------|-----|-----|---------|------------|
| NLL              | 85 | 0.2778 | 9193.0 | 0.3000 | 0.0000 | Rejected $H_0$ |
| CL               | 85 | 0.0000 |       |      |         |            |

Table 8 shows that the students’ KONDA gain scores of the students who learn OT content in NLL model are significantly better than those who learn OT content in CL model. On the other hand, based on normality test in Table 4, the statistical testings that can be used to compare KONDA gain score between OT content models in each SPK levels are the $t$-test and Mann-Whitney tests statistic.

Table 9. The summary of $t$-test for compare KONDA score for students in high level of SPK between two models of OT content

| SPK Level | OT Content Model | N  | Average | Std. Dev | df  | t     | p-value | Conclusion |
|-----------|------------------|----|---------|----------|-----|-------|---------|------------|
| High      | NLL              | 23 | 0.354   | 0.409    | 34  | 1.62  | 0.057   | Rejected $H_1$ |
|          | CL               | 13 | 0.126   | 0.401    |      |       |         |            |
Table 10. The summary of Mann-Whitney test statistic for compare KONDA score for students in low and moderate levels of SPK between two models of OT content

| SPK Level | OT Content Model | N  | Median | W    | Z     | p-value | Conclusion |
|-----------|------------------|----|--------|------|-------|---------|------------|
| Moderate  | NLL              | 52 | 0.232  | 3639.5 | 0.2321 | 0.0000 | Rejected H₀ |
|           | CL               | 57 | 0.000  |       |       |         |            |
| Low       | NLL              | 10 | 0.381  | 179.5 | 0.5313 | 0.0033 | Rejected H₀ |
|           | CL               | 15 | -0.143 |       |       |         |            |

Table 9 and Table 10 show that for students in the low or moderate level of SPK, the KONDA gain score between the students who learn OT content in NLL model is significantly better than those who learn OT content in CL model. Meanwhile, for students in the high level of SPK, the KONDA gain score between the students who learn OT content in NLL model is not significantly different with those who learn OT content in CL model. Based on those results shows that, in general, NLL model that implemented in OT content can enhance students’ KONDA. Furthermore, the enhancement of KONDA of students who have high SPK’s score, they have understood the explanation of normal distribution application from the printed material before they learn OT content in both models. Therefore, extra and a more challenging didactical situation is needed to make them achieve the significant gain score.

5. Conclusion and Implication

The results of data analysis in this study show that there is the difference in the gain score of knowledge on normal distribution application between students who learn online tutorial content in non-linear learning model and those who learn online tutorial content in conventional learning model. This results also states that there is the difference in the gain score of KONDA between students who have low, moderate and high statistical prior knowledge after they learn online tutorial content in two different ways. It can also be shown that there is the difference in the gain score of knowledge on normal distribution application between students who learn online tutorial content in non-linear learning model and those who learn online tutorial content in conventional learning model on each level of students’ statistical prior knowledge. The study also gives empirical evidence that the gain score of knowledge on normal distribution application for students who learn online tutorial content in non-linear learning model better than those who learn online tutorial content in conventional learning model. Finally, for students with low and moderate statistical prior knowledge, this research finds that the gain score of knowledge on normal distribution application for students who learn online tutorial content in non-linear learning model is better than those who learn online tutorial content in conventional learning model. Therefore, in general, online tutorial content in non-linear learning model can help students who have learning difficulties in understanding printed material independently. Meanwhile, for students who have high SPK’s score, they have understood the explanation of normal distribution application from the printed material before they learn OT content in both models. This can only mean that extra and a more challenging didactical situation is needed to make them achieve the significant gain score.

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