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The Effect of HPLC Interactive Multimedia Use on Students' Analytical Thinking Skills

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Abstract. Analytical thinking is one of the thinking skills that must be possessed by prospective teacher students, especially in studying HPLC material. The COVID-19 pandemic has caused limited practicum activities, so the MMI HPLC is expected to be a solution for students in learning the concept as a whole and continue to develop analytical thinking skils. The purpose of this study was to determine the effect of using HPLC Interactive Multimedia, either directly or indirectly, on the analytical thinking skills of prospective teacher students described through path analysis using the Structural Equation Model (SEM) approach based on variance or Partial Least Square (PLS). This study uses a quantitative approach through a questionnaire which is measured on a Likert scale. Based on the seven latent variables of student perception, the aspect of material meaningfulness when using MMI HPLC (X3) has a very strong influence in increasing student interest, motivation, curiosity, and activeness. Interest, motivation, curiosity, and activeness of students have an effect on building students' analytical thinking skills. On the meaningfulness material variable, it consists of 2 indicators, namely the media used to clarify students' understanding of the learning material and the media used appropriately and in accordance with the learning method. PLS SEM analysis is effectively used to analyze pathways or determine the effect of using HPLC interactive multimedia on students' analytical thinking skills through the provision of student questionnaires.
Keywords: analytical thinking skills, MMI HPLC, PLS SEM

Introduction

Analytical thinking is one of the most basic higher-order thinking skills to hone 21st century skills such as critical thinking, problem solving, creativity, and decision making so that analytical thinking skills are very important for prospective teacher students to have as a basic ability. Marzano (2008) suggests an operational definition of low-level thinking skills, which involves accessing and understanding existing knowledge, while higher-order thinking skills involve the creation of new knowledge (Dubas, 2016). Thinking analytically is needed especially in solving a problem. However, systematic techniques and frameworks are needed to speed up finding solutions to these problems. Analysis is a process that is

carried out carefully by dividing the problem through the application of technical analysis and the application of appropriate knowledge (Kao, 2014).

One application of analytical thinking skills, for example in analytical chemistry learning on High Performance Liquid Chromatography (HPLC) material, is one of the most widely used analytical techniques that can determine what types of components are contained in a sample (qualitative), and also determine how much components in a sample (quantitative). In studying this material, students must master basic concepts, parameters, sample preparation, HPLC instrument operation techniques, and analysis of chromatogram results (Yulina et al, 2019). However, for students, the many interrelationships of experimental variables that affect the results of each chromatographic analysis pose difficulties of its own because there are several parameters that affect the quality of separation such as physicochemical properties, dissolved molecular weight, properties, composition, temperature, flow rate of the mobile phase, and chemical properties. stationary phase (Usman et al, 2020; Bowen et al, 2018; Donoso-Tauda, 2019; Cecchi, 2018). Of course, this can be mastered by students if learning is accompanied by practicum. Irwanto et al. (2017) stated, students will find various kinds of problems and solve many problems independently through. In addition, students will have some hands-on experience in the concept discovery process, and the concepts acquired through practicum will have a long-term memory effect. The COVID-19 pandemic has had a dramatic effect on lives around the world (Sands, 2021), all learning activities have become very limited, especially practical activities. The results of pre-test students at LPTKs in Central Java showed results that were still very low, namely 27.7 ± SD 15.4.

The explanation of the concept of Analytical Chemistry can be done using various relevant methods and strategies to make it easier for students to understand. Education experts often recommend that in carrying out the learning process teachers should use complete media, according to needs and touch various senses. The learning process is a communication process that requires media, so that learning media is an important element in its successful implementation (Widayat et al, 2014). Therefore, the use of multimedia is a good alternative for teaching and learning to answer the challenges of learning in the 21st century, which are very dependent on information and communication technology (ICT) skills. The role of information technology is currently the most dominant sector. With information technology, limitations in the implementation of education can be overcome, either through web based distance learning, digital libraries, educational administration systems (Rafdhi, 2011).

Several previous research results reported that the use of interactive multimedia can improve students' higher-order thinking skills, such as critical thinking (Gunawan et al, 2019; Nurhayati et al, 2021; Al-Mar'ati; Aurum & Surjono, 2021), creative (Marnita, 2017; Hakim et al, 2017; Liliasari et al, 2016; Yulianci et al, 2021; Darmawan et al; 2020), collaboration (Hendarwati et al, 2021; Leow & Neo, 2013; Setiawan et al, 2019), and communication (Purnamasari & Herman, 2016; Syukri et al, 2020; Susilawati et al, 2018).

To match the demands of these targets, one of the ICT-based learning media was developed, namely interactive multimedia HPLC assisted by an HPLC simulator to improve students' conceptual understanding and at the same time improve the analytical thinking skills of prospective teacher students on HPLC material in analytical chemistry lectures. This study aims to determine the effect of using HPLC Interactive Multimedia either directly or indirectly on the analytical thinking skills of prospective teacher students which is described through path analysis using the structural equation model (SEM) approach based on variance or partial least square (PLS). Huang (2021) using PLS-SEM model to explore the influencing factors of learning satisfaction in blended learning.

Methods

This study uses a quantitative approach, with a quasi-experimental method to determine the direct or indirect effect of using MMI HPLC through a questionnaire given to students as a data collection tool. The research sample consisted of 35 students. In measuring a variable, a Likert scale is used as a tool to measure the variables that are the object of research. The data analysis technique in this study used PLS.

SEM with PLS is an alternative technique in SEM analysis where the data used does not have to have a multivariate normal distribution. In SEM with PLS the value of the latent variable can be estimated according to the linear combination of the manifest variables associated with a latent variable and treated to replace the manifest variable (Arfian & Yoraeni, 2019). The stages used in the data analysis carried out in this study consisted of:

a. Structural model (Inner model)

The structural model or inner model describes a model of the relationship between latent variables that is formed based on the substance of the theory.

b. Measurement model (outer model)

The measurement model or outer model describes the relationship between the latent variable and its manifest variable (indicator). In the outer model, there are two types of models, namely the formative indicator model and the reflexive indicator model. The reflexive model occurs when the manifest variable is influenced by the latent variable, while the formative model assumes that the manifest variable affects the latent variable with the direction of causality flowing from the manifest variable to the latent variable.

c. Weighting scheme (weight relation)

This third part is a special feature of SEM with PLS and is not present in covariance-based SEM. According to (Abdillah & Jogiyanto, 2015), the weight relation shows the relationship between the variance values between indicators and their latent variables.

d. Latent variable.

Description of latent variables and their manifest variables are as follows:

1) The exogenous latent variable of the suitability of the use of media has 2 manifest variables (indicators), namely, the suitability of the use of media to learning outcomes stated by X1.1; the suitability of the use of media to the learning material stated by X1.2.
2) The exogenous latent variable of the lecturer's role has 6 manifest variables (indicators), namely, media mastery as stated by X2.1; use of the language stated by X2.2; interaction with students stated by X2.3; Provide an opportunity to ask questions stated by X2.4; the accuracy of the answers stated by X2.5; feedback on the practice questions stated by X2.6;
3) The exogenous latent variable of material significance has 2 manifest variables (indicators), namely, MMI HPLC clarifies students' understanding as stated by X3.1; The media used is appropriate and in accordance with the learning method stated by X3.2.
4) The exogenous latent variable according to the student's condition has 2 manifest variables (indicators), namely, the media used is in accordance with the student's

abilities stated by X4.1; The media used to support students in obtaining new information stated by X4.2.

5) The exogenous latent variable of the suitability of the use of media with its function has 3 manifest variables (indicators), namely, the media used is easy to operate, which is stated by X5.1; The efficient media used is stated by X5.2; The media used is flexible which is stated by X5.3.
6) Endogenous latent variables Interest, motivation, curiosity, and student activity have 4 manifest variables (indicators), namely, MMI HPLC increases student demand as stated by Y1.1; The media used to increase student motivation stated by Y1.2; The media used to increase students' curiosity, stated by Y1.3; and the media used to increase student activity, stated by Y1.4.
7) Endogenous latent variables The improvement of students' analytical thinking skills has 5 manifest variables (indicators), namely, the matching aspect is stated by Z1.1; the classifying aspect stated by Z1.2; the error analysis aspect stated by Z1.3; the inferring aspect stated by Z1.4; and detailing aspects stated by Z1.5.

Results and Discussion

Students' perceptions were revealed to determine the extent of success in learning the HPLC material through a closed questionnaire with assessment indicators strongly agree, agree, moderately agree, disagree, and strongly disagree. As for some aspects of student perceptions carried out in this study are assumed to be latent variables, including: (1) The suitability of the use of media to learning outcomes and materials, (2) The role of lecturers in the learning process and utilization of learning media, (3) The meaning of the material when using media learning process (MMI HPLC), (4) the suitability of the media with student conditions, (5) the suitability of the use of media with its function, (6) interest, motivation, curiosity, and activeness of students in using MMI HPLC, (7) the media used is capable of improve students' analytical thinking skills. Each of these latent variables consists of their respective constituent indicators.

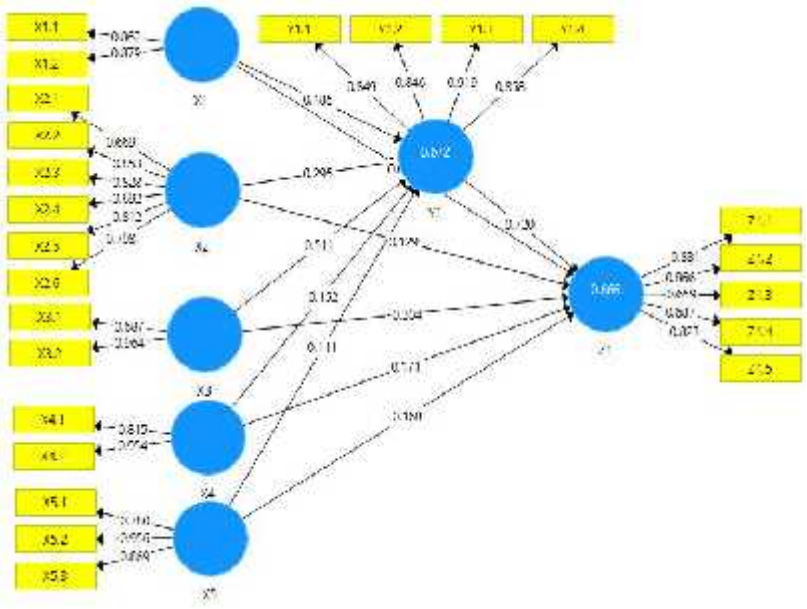

Figure 1. Results of path analysis between exogenous and endogenous variables

Based on the seven latent variables of student perceptions, they are grouped into 3 (three) types of variables, namely independent variables, consisting of the 1st to 5th indicators, intermediate or intervening variables, namely the 6th indicator, and the dependent variable, namely the 7th indicator. To find out the relationship between these variables, the analysis of the results of student perceptions uses the SEM approach based on variance or PLS. The evaluation carried out for each PLS scheme used is the evaluation of the measurement model (outer and inner model), namely the reflective model path scheme. The results of the path model analysis between variables are shown in Figure 1.

The measurement analysis of the outer model for reflective indicators includes an assessment of the validity and reliability of each indicator on its latent variables. Based on the results of Figure 1, the value of outer loading for each latent variable, there are 2 latent variables that have a value less than 0.7, namely X2 (X2.1 and X2.4) and X3 (X3.1). However, this value is not less than 0.4 so that in the analysis no indicators are excluded from the calculation. Each latent variable must be able to explain the variance of each indicator by at least 50%. Therefore, the absolute correlation between latent variables and their indicators must be > 0.7 (the absolute value of the outer raw loadings or called the outer loadings) (Ramayah, et al, 2016). Thus, each statement indicator given in the student perception questionnaire about the use of MMI HPLC, the role of the lecturer in the learning process, the meaning of the material, the student's condition, the suitability of the use of media with its function, interests, motivation, curiosity, and student activity, as well as the media used being able to improve students' analytical thinking skills can be said to be able to reflect the latent variables. This is also reinforced by the results of the reliability and construct validity calculations as described in Table 1.

Table 1. Construct Reliability and Validity

Variabel Laten	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
X1	0,682	0,684	0,863	0,758
X2	0,859	0,889	0,893	0,583
X3	0,639	1,121	0,820	0,701
X4	0,754	0,995	0,881	0,788
X5	0,842	0,879	0,904	0,759
Y1	0,892	0,902	0,925	0,754
Z1	0,833	0,848	0,883	0,605

Based on the results in Table 1, the convergent validity obtained from the average value of the extracted variance (AVE) shows the results > 0.5. Thus, each of the indicators that make up the latent variable already represents one latent variable or one latent variable capable of explaining more than half of the variance of the indicators on average. While the reliability value can be obtained from the Cronbach alpha value (outer absolute standard loading with a value > 0.7. So if < 0.7 then it is not reliable), or composite reliability (Measurement of internal consistency with a value of 0.6. So if < 0.6 then it is not reliable). Based on the results obtained, the value of Cronbach's alpha for X1 and X3 <0.7 so that the outer loading for these two variables is not reliable. While the composite reliability value for all variables > 0.6 so that the internal consistency measurement is entirely reliable.

Discriminant validity is an additional concept which means that two conceptually different concepts must show sufficient difference. The point is that a combined set of indicators is not expected to be unidimensional. To ensure discriminant validity, the AVE for each latent variable must be higher than R2 with all other latent variables. Thus, each

latent variable shares more variance with each of its indicator blocks than with other latent variables representing a different block of indicators. The value of R2 for Y1 is 0.672 and Z1 is 0.666. Based on the given R2 value, all AVE values of the latent variables show results > R2, except for X2 with an AVE value of 0.583.

Furthermore, the results of the measurement of the inner model or structural model are to determine the relationship between latent variables. In this case, the measurement of the inner model can be obtained from the endogenous latent R2 value, estimated path coefficient, f2 influence size, prediction relevance, and beta values for path coefficients in PLS SEM.

Table 2. R2 laten endogenous

	R Square	R Square Adjusted
Y1	0,672	0,616
Z1	0,666	0,594

According to Chin (1998) in Ghozali (2012), R-square is the percentage value of the amount of data from independent variables that jointly affect the dependent variable, while the value of 1 – (r-square) is a value that cannot be explained in the model. or what we call the error value. The R2 value of the endogenous latent variable for both Y1 and Z1 of 0.67 is categorized as substantial or good category. Meanwhile, to determine the effect of latent predictor variables (exogenous) on the structural arrangement, it is shown at the value of f2 as shown in Table 3, with an explanation of the results as follows:

a. The latent variables X5 Y1 and X1 Z1, have a value of f2 < 0.02 so they are categorized as weak influence of latent predictor variables (exogenous latent variables) at the structural level,
b. The latent variables X1 Y1, X2 Y1, X4 Y1, X2 Z1, X3 Z1, X4 Z1, and X5 Z1, are categorized as having sufficient influence on the latent predictor variables (exogenous latent variables) at the structural level, because the value obtained 0.02<f2<0.15,
c. The latent variables X3 Y1 and Y1 Z1 were categorized as having a strong influence on the latent predictor variables (exogenous latent variables) at the structural level, because the value of f2 > 0.15 was obtained.

Table 3. The effect of the predictor latent variable using the result of the f2 value

	X1	X2	X3	X4	X5	Y1	Z1
X1						0,043	0,006
X2						0,131	0,022
X3						0,294	0,079
X4						0,038	0,045
X5						0,020	0,044
Y1							0,508
Z1							

This result is also in line with the f2 value of the two variables which are categorized as a strong influence of latent predictor variables (exogenous latent variables) at the structural level. This result is also strengthened by the value of the total effect on the path coefficient as described in Table 4.

Table 4. The total effect of path analysis

	X1	X2	X3	X4	X5	Y1	Z1
X1						0,185	0,203
X2						0,295	0,341
X3						0,511	0,064
X4						-0,152	0,061
X5						0,111	0,248
Y1							0,720
Z1							

Based on the results of the total effect value in Table 4, the path coefficients value ranges from -1 to +1. Where if the value of the path coefficients is getting closer to the value of +1, the relationship between the two constructs is getting stronger. The relationship that is closer to -1 indicates that the relationship is negative (Sarstedt et al, 2018). Thus, the conclusion of the analysis of the total effect of the inner model in the picture above is:

a. The biggest direct effect is Y1 on Z1, of 0.720, which means that if Y1 increases by one unit, Z1 can increase by 72.0%. This influence is positive.
b. The second largest direct effect is X3 on Y1, of 0.511, which means that if X3 increases by one unit, Y1 can increase by 51.1%. This influence is positive.
c. The direct effect of X4 on Y1 is -0.152, which means that if X4 increases by one unit, Y1 can increase by -15.2%, but this effect is negative.

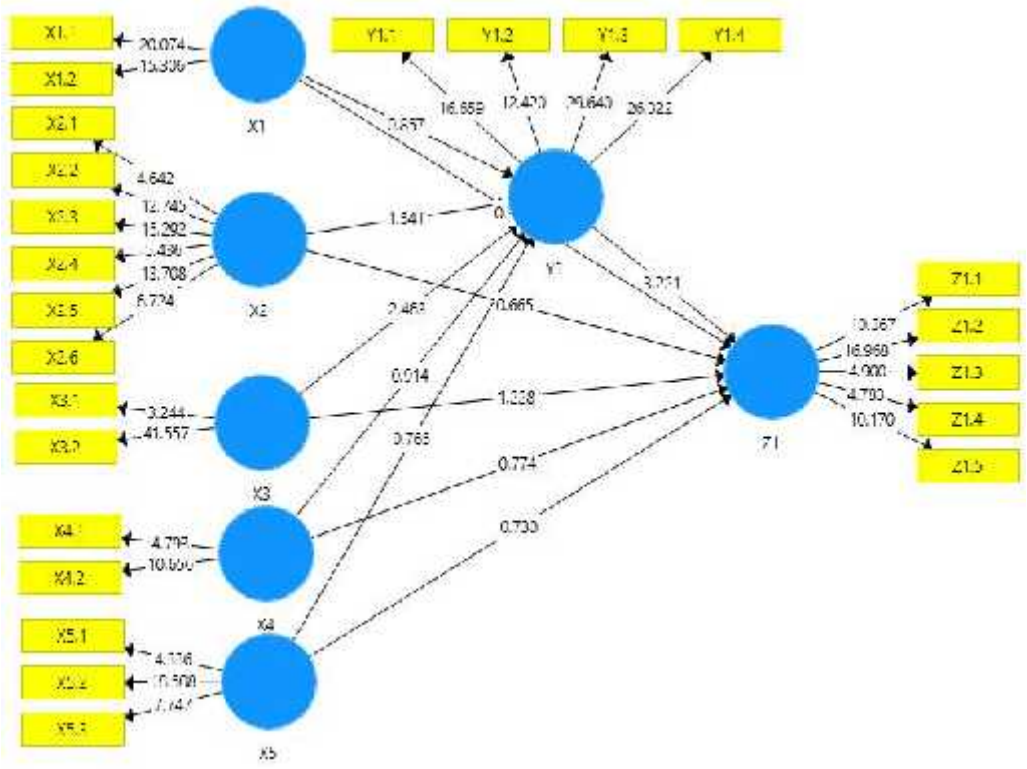

Figure 2. A bootstrapping process of path analysis

The significance test on the SEM model with PLS aims to determine the effect of exogenous variables on endogenous variables (Arfian & Yoraeni, 2019). Hypothesis testing with the PLS SEM method is carried out by performing a bootstrapping process with the help of the smartPLS 3.0 computer program so that the relationship between the influence of exogenous variables on endogenous variables is obtained with the results of the path analysis in Figure 2.

Before testing the hypothesis, it is known that the value of the T-table for the 95% confidence level (α 5%) and the degrees of freedom (df) = n-2 = 35–2= 33 is 1.69. Hypothesis testing for each latent variable relationship is shown in Table 5.

Table 5. The final results of testing the sample mean, standard deviation, T statistic, and P value

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
X1 -> Y1	0,185	0,106	0,216	0,857	0,392
X1 -> Z1	0,070	0,049	0,219	0,320	0,749
X2 -> Y1	0,295	0,342	0,191	1,541	0,124
X2 -> Z1	0,129	0,165	0,194	0,665	0,506
X3 -> Y1	0,511	0,509	0,207	2,463	0,014
X3 -> Z1	-0,304	-0,297	0,247	1,228	0,220
X4 -> Y1	-0,152	-0,076	0,167	0,914	0,361
X4 -> Z1	0,171	0,197	0,221	0,774	0,440
X5 -> Y1	0,111	0,068	0,145	0,765	0,445
X5 -> Z1	0,168	0,158	0,230	0,730	0,466
Y1 -> Z1	0,720	0,674	0,223	3,221	0,001

Hypothesis Testing The significance of the material when using MMI HPLC (X3) on the variables of interest, motivation, curiosity, and student activity in using MMI HPLC (Y1) of 2.463 > Ttable (1.69). The original sample estimate value shows a positive value of 0.773 which indicates that the direction of the relationship of the material meaningfulness variable when using MMI HPLC (X3) to the variables of interest, motivation, curiosity, and student activity in using MMI HPLC (Y1) is positive. Thus H11 in the study was accepted. That is, in this study the latent variable The significance of the material when using MMI HPLC (X3) with its indicators affected the latent variables of interest, motivation, curiosity, and student activity in using MMI HPLC (Y1) with the indicators significantly.

This is in line with the research of Hendarwati (2021), who has developed CPMM (collaborative problem solving based on mobile multimedia), which consists of three main features, namely: homepage, collaborative, and evaluation. The presence of mobile interactive multimedia that presents elements of collaborative discussion is effective in improving student achievement. Research conducted by Kurniawati (2019) on the effectiveness of interactive multimedia in facing educational challenges in the industrial era 4.0 also shows positive results, namely that the use of interactive multimedia can improve learning outcomes and students' critical thinking skills at both the junior high and high school levels.

Furthermore, another positive relationship is found in the hypothesis testing of the variables of interest, motivation, curiosity, and student activity in using MMI HPLC (Y1) on the media variables used to improve students' analytical thinking skills (Z1), with a statistical T value of 3,221 > T- table (1.69). The original sample estimate value shows a

positive value of 1.531 which indicates that the direction of the relationship between the Y1 variable and the Z1 variable is positive. Thus H12 in the study was accepted. That is, in this study the latent variables of interest, motivation, curiosity, and student activity in using MMI HPLC (Y1) with the indicators affecting the latent variables the media variables used were able to improve students' analytical thinking skills (Z1) with the indicators significantly. Increasing students' motivation and involvement in learning by using digital games is proven to be able to improve student learning achievement (Saprudin, et al, 2019).

While the other four aspects, namely the use of media on achievement and learning materials, the role of lecturers in the learning process and the use of learning media, the suitability of the media with student conditions, the suitability of the use of media with its function, does not affect the interests, motivation, curiosity, and activeness of students , because the statistical T value of the 4 aspects has a statistical T value < T table. Thus H13 is rejected so that the latent variables of the four latent variables (X1, X2, X4, and X5) with their indicators have no effect on the latent variables of interest, motivation, curiosity, and student activity (Y) with the indicators significantly, so that it does not affect students' analytical thinking skills (Z1). Students have only worked on the cognitive system so far, according to the hypothesis revealed through Marzano's Taxonomy (Dubas & Toledo, 2016; Sriutai, 2015). Meanwhile, three interconnected mental systems, namely information, mental procedures, and psychomotor procedures, are required to attain higher order thinking skills. Students' knowledge is expanded during the analysis phase as they uncover new linkages and applications (Montaku, 2011).

The highest original sample estimate value that affects students' analytical thinking skills (Z1) is on the material meaningfulness variable (X3) along with the increasing interest, motivation, and activeness of students in using MMI HPLC. This means that the effect of the meaningfulness of the material does not directly affect the results of students' analytical thinking skills, but gradually increases students' interest, motivation, curiosity and activeness. Thus, it can be concluded that the most influential factor in improving students' analytical thinking skills is the use of MMI HPLC which is able to clarify students' understanding of learning materials and the media used are appropriate and in accordance with learning methods. This is in line with research conducted by Istiqlal (2014), interactive learning media has great potential to stimulate students to respond positively to the learning material presented. The results of research by Karenina, et al. (2020) show the effectiveness of analytical thinking by using the integration of aspects of problem solving and analytical thinking in the human respiratory system material. Aspects of problem solving are identifying, defining, exploring, acting, and looking back, while aspects of analytical thinking are differentiating, organizing, and attributing.

Analytical thinking is a powerful thinking tool for understanding parts of a situation defined as: (1) the ability to research and parse facts and thoughts through strengths and weaknesses; (2) develop the capacity to think wisely, intelligently, solve problems, analyze data, remember, and use information (Chonkaew et al, 2016). In Bloom's taxonomy, the analytical aspect ranks fourth after knowledge, understanding, and application. The ability to think analytically is a basic ability that must be possessed by students and cannot be achieved if the student does not master the previous cognitive aspects. According to Winarti (2015), analysis is a complex type of result because it utilizes elements of knowledge, understanding and application. In this case, the use of MMI HPLC is very helpful in understanding and applying students in using HPLC instrumentation which is quite complex. This analytical ability also includes the ability to solve non-routine questions, find relationships, prove and comment on evidence, and formulate and show the truth of a generalization, but it is only in the analysis stage that it has not been able to compile.

Another opinion that is in line, Irwanto. et al. (2017) states that analytical ability is the ability to detail or describe a problem (question) into smaller parts (components) and

be able to understand the relationship between these parts. This is also reinforced by Bloom who states that the ability to think analytically emphasizes breaking down material into more specific or smaller parts and detecting relationships and the parts and parts are organized.

Conclusion

The effect of using HPLC Interactive Multimedia on the analytical thinking skills of prospective teacher students consists of direct and indirect effects. The results of the path analysis show that the variables of interest, motivation, curiosity, and student activity (Y1) have a direct effect on the variables of students' analytical thinking skills (Z1) with the indicators significantly, and the variable meaningfulness of the material when using learning media (X3) has a direct effect. on the variables of interest, motivation, curiosity, and student activity (Y1). Meanwhile, the indirect effect of using IMM HPLC on students' analytical thinking skills is influenced by the suitability of the use of media to achievement and learning materials (X1), the role of lecturers in the learning process and utilization of learning media (X2), and the suitability of the media with student conditions (X4).

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