Competency Test Framework for Application of Electronic Circuits for Audio Video Engineering Vocational High School Students

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Abstract. This study aims to develop and analyze the Competency Test instrument for Application of Electronic Circuits for students of class X and XI of SMK Audio Video Engineering Expertise Program by modeling Item Response Theory. In developing and analyzing the instrument using the validity of Messick (1996) with an approach consisting of three aspects including content, substantive and structural. This Expertise Competency Test instrument includes materials for reading electronic diagrams/schematics, using unit units, reading and identifying electronic components (passive), reading and identifying electronic components (active), designing and manufacturing single/double layer PCBs (printed circuit boards) manually. manuals using the iron transfer artwork method, using test and measuring equipment, using basic electrical and electronic components, tracking damage to electronic products and developing engineering solutions for analog electronics problems presented in the form of multiple choice questions. Each question refers to each element of competence in each unit of competence. The research design uses the ADDIE procedural model (Analysis, Design, Development, Implementation, Evaluation). The research subjects were planned to consist of 283 students of class X and XI of the Audio Video Engineering Skills Program at SMK Negeri 1 Adiwerna, Tegal Regency. Constructive validity with item response theory modeling is expected to give the following results: (1 The level of suitability of the items is in the range of -3 to 4; (2) The discriminative power of items is between 0 and 2, (3) False guesses are between 0 and 1, (4) All items are suitable for modeling; (3) There are no items containing DIF, so it can be said that the instrument is suitable for measuring the ability of the Electronic Circuit Application Expertise Competency for students of class X and XI of SMK Audio Video Engineering Expertise Program.

Keywords: Expertise Competency Test, Application of Electronic Circuits, Audio Video Engineering

1 Introduction

Vocational High Schools (SMK) organize education and training / training as an educational program tailored to the needs of employment. The subjects in Vocational High Schools (SMK) in each expertise program are divided into 3 (three) subject groups, namely, (1) subjects related to national / normative content, (2) subjects on regional / adaptive content and (3) subjects of vocational / productive specialization content. One of the things that supports the academic ability of students to be skilled at being ready to work is subjects

related to vocational/productive specialization content. Productive subjects function to equip students to have work competencies according to the Indonesian National Work Competency Standards (SKKNI).

The learning process at Vocational High Schools (SMK) at the end of the activity will be carried out an evaluation of expertise competencies which aims to find out whether students have met competencies or not in terms of the world of work. One that can be utilized is assessment or assessment activities to measure the extent of success in the productive / practical learning process. The implementation of this assessment or assessment is carried out in the form of a Expertise Competency Test (UKK). With the competency test, which involves the world of work, it can assess the competencies obtained by students at school, which are appropriate or not needed in the world of work.

The objectives of the implementation of the Expertise Competency Test (UKK) include aiming to 1) Measure the achievement of the competencies of SMK students who have completed the learning process according to the expertise competencies taken, 2) Facilitate SMK students who will complete their education to get competency certificates and / or competency test certificates, 3) Optimize the implementation of competency certification oriented towards the achievement of competencies of SMK graduates according to the National Qualifications Framework Indonesia and 4) Facilitating SMK cooperation with the business world, industry and the world of work (DUDIKA) in the context of implementing the Competency Test according to the needs of DUDIKA (Directorate ofSMK, 2021).

Based on the Indonesian National Qualifications Framework / KKNI level 2 scheme, the competence of Audio Video Engineering expertise can be achieved through a cluster approach and must be achieved within 3 (three) years of vocational education. The clusters used include the Application of Electronic Circuits (with 9 competency units and 35 competency elements), Audio Video Planning and Installation (with 9 competency units and 34 competency elements) and the Application of Radio and Television Systems (with 10 competency units and 40 competency elements) (Directorate ofSMK, 2021).

The Expertise Competency Test (UKK) is carried out in the workplace and / or institutions / schools that can provide facilities for implementing competency tests. The preparation of material for the Expertise Competency Test (UKK) is prepared by teachers / assessors based on a certification scheme in accordance with the qualification level of test / assessor participants which contains the ability to carry out specific work, operations, and / or quality assurance. For the elaboration of test questions refers to the number of competency units and elements of competence that exist. Expertise Competency Test (UKK) test instruments can be in the form of assignments / practices or other forms that are assessed individually to make a product / service according to competency standards. This form of expertise competency test can be in the form of written questions related to knowledge in accordance with the expertise program as well as a demonstration test of expertise practice. Knowledge aspect testing instruments can be multiple-choice questions, descriptions, short answers, and/or interviews. All questions are expected to produce good quality questions by adjusting the subject matter to be tested. Good questions will be able to naturally select smart learners and less intelligent learners through the results of student learning evaluation (Muh. Syahrul Sarea, 2019).

Related to the UKK questions used, the form of UKK questions used is an objective form question, one of which is a multiple choice test, the multiple choice test form can be used to measure memory, comprehension, and complex application abilities. In the multiple choice test, the answer must be selected from several answers provided so that multiple choice has the advantage of having a wider scope of material on the questions asked, having a higher

level of validity and reliability than essay or description questions. Thus the questions used must go through several stages in order to produce quality questions.

The material for the Expertise Competency Test (UKK) is prepared based on a certification scheme in accordance with the qualification level of the test / assessor participants which contains the ability to carry out specific work, operations, and / or quality assurance. The certification scheme is a package of competencies and specific requirements relating to certain categories of positions (occupations) or skills of a person (BNSP, 2021).

The following is presented in the table of competency units used as material for the Expertise Competency Test (UKK) for the Application of Electronic Series at Audio Video Engineering Vocational Schools (DirectorateSMK, 2021).

Table 1. Competency Unit for the Application of Electronic Circuits (PRE)

1. Unit Title	**: Reading Images / Skematics Electronic Diagrams**
Elements of Competence	
1. Memahami symbol of electronic components and working circuits skematik 2. Embeddingahkan in the component list / part list 3. Knowing the changes and *up-date* skema	
2. Unit Title	**: Using Unit Size**
Elements of Competence	
1. Reading bof the unit 2. Applying in electronic instruments and measurements	
3. Unit Title	**: Reading and Identifying Electronic Components (Passive)**
Elements of Competence	
1. Setting up the job 2. Reading andIdentifying Resistor Components 3. Reading andidentifying capacitor components 4. Read dan identify the Inductor component	
4. Unit Title	**: Reading and Identifying Electronic Components (Active)**
Elements of Competence	
1. Setting up the job 2. Reading andidentifying transistor components 3. Reading andidentifying thyristor components 4. Reading dan identify diode components 5. Reading dan identificasi optical components	
5. Unit Title	**: Designing and Making Single / Double Layer PCB (Printed Circuit Board) Manually with Iron Transfer Artwork Method**
Elements of Competence	
1. Setting up Schematic Capture (Memahami electronic circuit drawings) and work 2. Create PCB Board Design – (Physical Layout PCB) 3. Create the Printing Artwork (paper) 4. Perform Iron Transfer Artwork 5.Laundry Sink 6. Etching 7. Cutting and Drilling 8. Masking (When required)	

6. Unit Title	**: Using Test and Measuring Tools**
Elements of Competence	
1. Using a *measuring instrument Multimether* 2. Using *Osciloscope measuring instrument (Audio Video only)*	
7. Unit Title	**: Using Basic Electrical and Electronic Components**
Elements of Competence	
1.Identifying and using electrical components dan electronics 2.Using basic math and formulas 3.Applying the basic theory of electricity and electronics 4.Using basic electronics circuits 5. Using optical electronics	
8. Unit Title	**: Tracking Damage to Electronic Products**
Elements of Competence	
1. Prepare for the job of tracking damage (troubleshooting) 2. Analyzing / diagnosing damage to electronic products 3.Perform cleaning and repair and testing.	
9. Unit Title	**: Developing enginering solutions for analog electronic problems**
Elements of Competence	
1.Setting up the development of engineering solutions for analog electronic problems 2.Develop engineering solutions to analog electronic problems 3.Implementing engineering solutions to analog electronic problems	

Arifin, (Asrul et al., 2014) , assessment is a systematic and continuous process or activity to collect information about the learning process and outcomes of students in order to make decisions based on certain criteria and considerations. Assessment is a process of collecting student data both during the learning process, as well as on learning outcomes. The tools used in the assessment are called assessment instruments. The assessment instruments used can be in the form of 2 types, namely tests and not tests / non-tests (Arikunto, 2016). As part of the objective test form, multiple choice is the most popular model of questions. According to (Susongko, 2010), the objective test form is more practical in its scoring, in the objective test form whoever checks will give the same score, so the error due to scoring can be small especially when used by a computer in scoring. The virtues of multiple choice form tests according to (Mardapi, 2017) include: 1) being able to measure low to high levels of thinking, 2) the scope of test materials can be more, 3) objective scoring, being able to use a computer. The collected data is then analyzed and the results of the analysis serve as feedback on the learning process, as well as as material for making decisions on the students' levels. (Ndiung & Jediut, 2020).

Some of the previous studies that are relevant to the problems to be studied related to the problem of developing vocational competency test questions for the Application of Electronic Circuits and the use of the Item Response Theory model are contained in the following research:

"Analysis of Characteristics of Mathematical Test Items on the Test Made by MGMP Mathematics in Makassar City Based on Modern Theory (Grain Response Theory)" (Syamsir Sainuddin, 2018); "Equalization of Academic Potential Question Tests Based on Item Response Theory Using R Software at STMIK AKBA" (Akbar Iskandar and Ahmad Rudi, 2017); "Analysis of Estimation of Students' Ability to Answer Physics Questions With the *Item Response Theory Approach* of Dichotomos and Polytomos" (Duden Saepuzaman et al, 2019). The development of this research shows that measuring the ability of vocational competencies is very important to be developed in the operational curriculum of educational units, especially in Vocational High Schools (SMK). The similarity of previous research is the similarity in the type of research, namely research on the development of multiple-choice questions with analysis using the grain response theory model. The differences are: (1) In Syamsir Sainuddin's research (2018), the assessment developed is a multiple choice test for UN Mathematics questions made by MGMP with 3 logistics parameters (difficulty of grains, differential power and pseudo-guessing), while the current research is the development of a competency test assessment model for the application of electronic circuits with 2 logistics parameters (difficulty of grains and different power) ; (2) In the research (Akbar Iskandar and Ahmad Rudi, 2017), the focus is on the development of academic potential tests while the current research is the development of competency test assessment models for the application of electronic circuits; (3) In the research of Duden Saepuzaman et al, (2019), focusing on the development of physics problems with 3 parameter logistics (grain difficulty, differential power and pseudo-guessing), while the current research is the development of a competency test assessment model for the application of electronic circuits with 2 parameter logistics (item difficulty and different power).

To obtain high-quality instruments, in addition to theoretical analysis (review of items based on aspects of content, construction, and language) it is also necessary to conduct an empirical analysis of the items. Broadly speaking, this empirical item analysis can be divided into two, namely with the classical test theory approach and the item response theory (IRT). Classical measurement theory has limitations, namely: (1) the statistics of the test items largely depend on the characteristics of the subject being tested; (2) the estimated ability of the examinee depends largely on the test item being tested; (3) the standard error in estimating the score applies to all examinees, so that the standard error of each participant's measurement and the question item does not exist; (4) the information presented is limited to the number of correct answers; and (5) the assumption of parallel tests is difficult to meet (Mari et al., 2012). So that the grain response theory (IRT) model is suitable for use so that the scoring does not change / invariant to the test items and to the test takers.

There are three kinds of logistics models used in the research of grain response theory, namely the one-parameter, two-parameter, and three-parameter models. The difference between the three models lies in the difference in the number of parameters used to describe the characteristics of the items in the model in question. According to (Saifuddin Azwar, 2012), the use of a model of some logistics from grain response theory is that the computational procedure with this model is simpler when compared to the computational procedure in other models.

(Hambleton et al., 1991) suggests: on the model one logistics relates the probability of answering correctly each item ($P(\theta)$) as a function of the ability (θ) with the constant degree of difficulty of item (b) through the relationship as in equation (1).

$$P_i(\theta) = \frac{e^{(\theta - b_i)}}{1+e^{(\theta - b_i)}}$$, where i = 1, 2, 3,...,n(1)

In the two-parameter logistics model, the probability of the test taker being able to answer correctly a question item is determined by two item characteristics, namely the difficulty of the item (*bi*) and the differentiability of the item (*ai*) through relationships as in persamaan (2).

$$P(\theta) = \frac{e^{Dai(\theta - b_i)}}{1+e^{Dai(\theta - b_i)}}$$, where i = 1, 2, 3,...,n(2)

In the three-parameter model is entered one more characteristic parameter of the grain, that is, the probability item to answer correctly by chance, which is better known by the name of the pscudo-chane level parameter. This parameter is symbolized by the letter *ci* through the relationship as in persamaan (3)

$$P(\theta) = ci + (1 - ci).\frac{e^{Dai(\theta - b_i)}}{1+e^{Dai(\theta - b_i)}}$$, where i = 1, 2, 3,...,n (3)

The application of the grain response theory model in learning achievement is now widespread not only in the world of education but also in the world of medicine and public health Also, to survey psychological aspects, related to science learning and some scientific aspects of literacy and the nature of science (Susongko et al., 2020). However, the competency test instrument for the application of electronic circuits has not been found in other studies. To develop this instrument, the following problems must be answered: The problem is for example how the test is constructed, the validity of the content and psychometric aspects and the validity of the construct. This research was conducted at the Audio Video Engineering Competency Vocational School, namely SMK Negeri 1 Adiwerna, Tegal Regency, Central Java, Indonesia. This research can be developed for other classes and schools.

Research Issues

In this study, it aims to develop and analyze competency test instruments for the application of electronic circuits with the principle of grain response theory. In developing and analyzing the instrument using the validity approach Messick (1996) which consists of three aspects, namely content, substantive and structural. The research problem is, is the competency test instrument for the application of electronic circuits developed according to the modeling of grain response theory suitable for students of SMK Audio Video Engineering Expertise Competency?

2. Research Methods

2.1 Research Design

This research uses a type of research and development or Research and Development (R&D). with the ADDIE prosedural model (Analysis, Design, Development, Implementation, Evaluation) (Sugiyono, 2019). At the analysis stage, the researcher determines the needs and goals of the product to be developed. This research product is an instrument that measures the competency test of expertise in the Application of Electronic Circuits in students of SMK Audio Video Engineering Expertise Competency.

At the design stage, the researcher begins to collect, compile and design the product to be developed. At the developmental stage, the researcher begins to validate the developed instrument. At the implementation stage, researchers make observations by providing tests in the form of competency tests for expertise in the Application of Electronic Circuits. At the evaluation stage, an external validity test is carried out using external criteria such as an intelligence test or a National Examination result test. For this research is limited to the stages of analysis, design and development (Susongko et al., 2020).

2.2 Subject and Time of Research

The subjects in this study were 283 students of class X and XI Audio Video Engineering Expertise Competencies of SMK Negeri 1 Adiwerna, Tegal Regency, while this research was carried out in the first semester of the 2021/2022 academic year.

2.3 Data Collection Instruments

The competency test for the Application of Electronic Circuits is presented in the form of multiple-choice questions, namely: consisting of 70 questions for the Application of Electronic Circuits to determine the level of students' high-level thinking ability. Questions are prepared by researchers for the expert review stage. The competency test material for the Application of Electronics Series expertise was reviewed by one person from the business world / industrial world and one electronics teacher from SMK Negeri 1 Adiwerna and one psychometric expert from Pancasakti Tegal University.

2.4 Data Analysis

Data analysis was carried out by dividing validity into three types, namely the validity of the content aspect, the validity of the psychometric aspect, and the validity of the construct by modeling the buitr response theory. Content validation is carried out with an assessment involving two experts related to the test material and the ability to test the competence of the Electronic Circuit Application expertise to be measured. Experts are asked to answer whether the question items have met several criteria such as: narratives according to the domain of learning outcomes in the subject of Application of Electronic Circuits, data-based narratives, each question item refers to the unit of competence and elements of competence and the answer key is correct.

Validation of psychometric aspects involves a psychometric expert related to the construction of testing. Aspects of the test construction assessed include material, construction, and language aspects.

As for the validity of constructs, which refers to the concept of construct validity (Messick, 1996), where the validity of constructs is divided into three aspecs, namely content, substantive and structural (Suseno et al., 2021). Quantitativek riteria according to (Susongko, 2019) which relates to construct validity indicators according to the grain response theory model as described in Table 2.

Table 2. Valid test criteria are viewed from various aspects of validity and criteria with the application of the grain response theory model.

Aspects of Construct Validity	Indicators	Criterion
Fill	Item match test (itemfit)	P>0.01

Substantive	Person/Item Map	testee ability equal to or close to item difficulty level
	Test Information Function	Test Information Function Has Maximum Value on Testee Domain
	Person fit statistics	P>0.01
Structural	Unidimensional Test	There is one main factor depicted through the screen plot of the results of the factor analysis

In this study, the software used in analyzing the grain response theory model used Program R version 4.0.3 with the eRM package. This software is used because it is open source, making it easy to access and develop for observers of educational assessment research.

3. Discussion

3.1 Test Grid

In order for the tests carried out to find out the true abilities of students, a good test kit is needed. A good test kit can be reviewed from different sides. First, the content of the test should be in accordance with the material to be tested, so that the validity is good. Secondly, the test has a good construct. Third, a good test must have a reliability. If used to measure several times, either on the same or different test takers, the results are relatively the same (Heri Retnawati, 2014).

In the design stage researchers begin to collect, compile and design the product to be developed. There are three things that are considered in compiling the grid and test items, namely the title of the competency unit, competency elements and performance criteria in the Application of Electronic Circuits and the validation model of the test items. The form of the test is given in the form of multiple choice questions, each of these test items pays attention to the competencies contained in the KKNI Level II Certification Scheme on Audio Video Engineering Expertise Competencies (BNSP, 2017). The grid of the tests is described in Table 3.

Table 3. Grid Uji Competency Expertise Application of Electronic Circuits

1. Unit Title	**: Reading Images / Skematics Electronic Diagrams**	**Problem Number**
Elements of Competence		
1. Understanding the symbols of electronic components and schematic work sets		1, 2
2. Translating in the component list / part list		3, 4
3. Knowing the changes and *up-date* skema		5, 6
Indicators : can read pictures and schematics of electronic diagrams yang applicable in the industry elektronica		
2. Unit Title	**: Using Unit Size**	
Elements of Competence		

1. Reading bof the unit 2. Applying in electronic instruments and measurements		7, 8 9, 10
Indicator : can memaca nilai komponen electronica d a n reading scale pera latan u ran reducerthat requires unit size conversion		
3. Unit Title	**: Reading and Identifying Electronic Components (Passive)**	
Elements of Competence		
1. Setting up the job 2. Reading andIdentifying Resistor Components 3. Reading andidentifying capacitor components 4. Read dan identify the Inductor component		11, 12 13, 14 15, 16 17, 18
Indicators: can read and identify passive components of Resistor-Inductance-Capacitor (RLC) electronics carried out in the industry as well as maintenance and repair of electronics.		
4. Unit Title	**: Reading and Identifying Electronic Components (Active)**	
Elements of Competence		
1. Setting up the job 2. Reading andidentifying transistor components 3. Reading andidentifying thyristor components 4. Reading dan identify diode components 5. Reading dan identificasi optical components		19, 20 21, 22 23, 24 25, 26 27, 28
Indicators: can read and identify active components of electronics carried out in the industry as well as maintenance and repair electronics.		
5. Unit Title	**: Designing and Making Single / Double Layer PCB (Printed Circuit Board) Manually with Iron Transfer Artwork Method**	
Elements of Competence		
1. Setting up Schematic Capture (Memahami electronic circuit drawings) and work 2. Create PCB Board Design – (Physical Layout PCB) 3. Create the Printing Artwork (paper) 4. Perform Iron Transfer Artwork 5.Laundry Sink 6. Etching 7. Cutting and Drilling 8. Masking (When required)		29, 30 31, 32 33, 34 35, 36 37, 38 39, 40 41, 42 43, 44
Indicator: can make PCB layouts on a medium until the PCB is ready to be used for assembly parts		

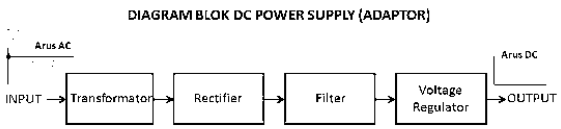
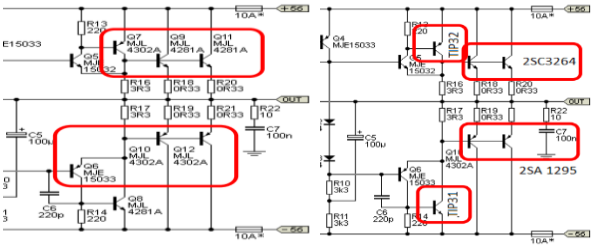
6. Unit Title	**: Using Test and Measuring Tools**	

Elements of Competence	
1. Using a *measuring instrument Multimether* 2. Using *Osciloscope measuring instrument (Audio Video only)*	45, 46 47, 48
Indicators: can use test and measuring tools	
7. Unit Title : **Using Basic Electrical and Electronic Components**	
Elements of Competence	
1.Identifying and using electrical components dan electronics 2.Using basic math and formulas 3.Applying the basic theory of electricity and electronics 4.Using basic electronics circuits 5. Using optical electronics	49, 50 51, 52 53, 54 55, 56 57, 58
Indicators: can use basic electrical and electronic components.	
8. Unit Title : **Tracking Damage to Electronic Products**	
Elements of Competence	
1. Prepare for the job of tracking damage (troubleshooting) 2. Analyzing / diagnosing damage to electronic products 3.Perform cleaning and repair and testing.	59, 60 61, 62 63, 64
Indicator : can look for damage to electronic products.	
9. Unit Title : **Developing enginering solutions for analog electronic problems**	
Elements of Competence	
1.Setting up the development of engineering solutions for analog electronic problems 2.Develop engineering solutions to analog electronic problems 3.Implementing engineering solutions to analog electronic problems	65, 66 67, 68 69, 70
Indicators : can include working safely, applying extensive knowledge of analog electronic circuits and device operations and their application, collecting and analyzing data, applying problem-solving techniques, developing and documenting solutions and alternatives	

3.2 Test Framework

At the development stage, a test instrument for the Competency Test of Expertise in the Application of Electronic Circuits was created. Examples of developed instruments are in the following table 4:

Table 4. Example of a test instrument Competency Expertise Application of Electronic Circuits

1. Unit Title	: Reading Images / Skematics Electronic Diagrams
Elements of Competence	**Multiple Choice Questions**
1.Memahami symbol of electronic components and working circuit skematik	1. Take a look at the following image:  The rectifier function is: **A. adjusting the current** B. filter ripple C. raising the voltage D. lowering the voltage
2. Embeddingin thelist of components / part list	2. Here's a misrepresentation of the skills required in translating in the component list/part list... A. Translating an electronic master partlist from a schematic source of diagrams B. Group the same types of components for easy subsequent processes **C. Knowing the safety part of the circuit image** D. Check the list of components/part lists of the network work system to obtain a valid circuit image
3. Know the changes and *up-date* skema	3. Take a look at the image below:  The following is a description in the picture above regarding the changes in the circuit update to the replacement of the components used... **A. MJL4302A (PNP) and MJE15033 (PNP) were changed to TIP31 and TIP32, then MJL4281A (NPN)**

	and MJL4302A (PNP) were changed to 2SC3264 and 2SA1295 B. MJL4302A (NPN) and MJE15033 (PNP) were changed to TIP31 and TIP32, then MJL4281A (PNP) and MJL4302A (NPN) were changed to 2SC3264 and 2SA1295 C. TIP31 and TIP32 were changed to MJL4302A (NPN) and MJE15033 (PNP), then 2SC3264 and 2SA1295 were changed to MJL4281A (PNP) and MJL4302A (NPN) D. TIP31 and TIP32 were changed to MJL4302A (PNP) and MJE15033 (NPN), then 2SC3264 and 2SA1295 were changed to MJL4281A (NPN) and MJL4302A (PNP)

9. Unit Title	: **Developing enginering solutions for analog electronic problems**
Elements of Competence	**Multiple Choice Questions**
1.Setting up the development of engineering solutions for analog electronic problems	1. Once you understand the electronic circuitry and equipment to be repaired (serviced), you can use.....and the logical sequence of tests to detect the source of the problem. A.circuit testing **B.reasoning/analysis** C.scanner diagnostic D.observations
2. Develop engineering solutions to analog electronic problems	2. When diagnosing consumer electronic product problems, you should first determine the..... what of..... which may cause symptoms. A.block section; Output B.block section; rectifier C.block section; Chip **D.block section; circuit (circuit)**
3. Applying engineering solutions to analog electronic problems	3. In the final inspection of a production process, an electronics technician finds a defective product, then the product will be marked ... A. G (Good) **B. NG (No Good)** C. QC (Quality Control) D. OK

4. Conclusions

In the preparation of the Competency Test Framework for the Application of Electronic Circuit Expertise, it is necessary to analyze: (1) analyze the needs and objectives of the product to be developed; (2) collect, compile and design products to be developed; (3) validate the instruments developed including validation of content aspects, validation of psychometric aspects and validation of constructs with grain response theory models.

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