

STRENGTHENING PROSPECTIVE TEACHERS OF BIOLOGY ON TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPCK)

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Abstract

This research was conducted for strengthening Technological Pedagogical Content Knowledge (TPCK) of prospective teachers of Biology based on Indonesian National Qualification Framework (NQF/KKNI). The research was carried out to fulfill Indonesian government's policy on NQF where college of education graduates must meet level-6 for undergraduate program and level-7 for the educational profession program. This development research aimed to design and develop a model to enhance the competency and competitiveness of College of Education graduates to meet the professional, social and industrial needs. The research employed Survey Cross Sectional method. This paper discusses a preliminary study of developed models for the Department of Mathematics and Biology Education and conducted through a survey of 243 students from four different colleges of education in the Province of Riau, Indonesia. The data were collected through a test, a set of questionnaire and interview. The instruments used contained seven variables of knowledge, namely Technology, Paedagogy, Content, Technological Paedagogy, Technological Content, Technological knowledge and TPCK. The instruments had been tested for their validity and reliability. Based on the data analysis two products were generated. First, a lesson design of an integrated learning in education and professional courses. Second, Workbooks entitled 'Problem for Student Drills and Practice and Teacher Competency Test. Research is still ongoing to produce the model for strenghtening TPCK for prospective teachers of Mathematics and Science.

Keywords: *Prospective teachers of Biology, Technological Pedagogical Content Knowledge (TPCK), Indonesian National Qualification Framework (NQF/KKNI).*

1. INTRODUCTION

The regulation of the government of the Republic of Indonesia number 19/2005 on National Education Standard and the government regulation number 32/2013 on the Amendment of Education National Standard paragraph 1, article 8 explicitly states that teachers and educational practitioners should meet the criteria and educational eligibility of both inservice training and on the job training. Teachers are professional educators whose main duty is to educate, teach, supervise, direct, train, assess and evaluate pupils in early educational level of formal education, primary education and secondary education. Professional teachers will produce good learning process and good quality education in an effort to achieve brilliant and competitive citizens, i.e. the ones who believe in the One Supreme God, with good attitude and behavior, being healthy, knowledgeable, smart, creative, independent, democratic and responsible citizens. To become professional teachers, teachers should possess knowledge to develop the competent aspects they have in them. Based on the government regulation number 14/2005 on Teachers and University Lecturers, it is stated that teacher competence includes pedagogical competence, professional competence, social competence and personal competence. These competencies for candidate teachers are obtained through Teacher Professional Education program (PPG).

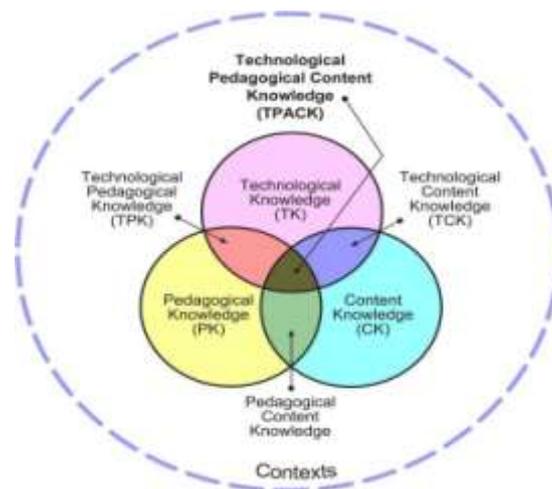
College of Education (LPTK) is a higher education institution that runs undergraduate and post graduate education and profession that put an emphasis on mastering educational disciplines based on Indonesian National Qualification Framework (KKNI) that prepares students to become candiadate teachers who can meet the educational needs. The limitation of human resources causes the implementation of Competence-Based-Curriculum (KBK) to achieve the Education National Standard being encoutered with various constraints. According to the director of KPS, Directorate

General for Higher Education (2008) curriculum development should lead to the achievement of competencies already set forth with accurate analysis that matches the the competency of a study program in higher education. The development of KBK of KKNi based is meant to develop the mentality of educators to create good quality human resources on the basis of their qualifications. This will lead to the international recognition towards the quality of competeive human resources. KKNi also encourages the building of the country education profile with comprehensive data.

Based on the above conditions, the effort to develop the quality and teachers professionalism is badly needed. This development can be made through developing the knowledge that teachers have that can support their profession, among others by strengthening *Technological Pedagogical Content Knowledge* (TPCK). TPCK is a framework of knowledge that shows the relationships of three kinds of knowledge that teachers must master; namely, technology, pedagogy, and content (the content of learning materials). Teachers should master TPCK in order to be able to design effective learning programs. TPCK was originally developed by Mishra and Matthew J Koehler and then was developed by Lee Schilman on Pedagogical Content Knowledge (PCK) (Abbit, 2011).

The TPCK model consists of three main components, i.e. content, pedagogy, and technology. These components are interactive with eath other that can be seen in the intersection of the diagram. From the framework, seven components of knowledge are present.

1. *Content Knowledge* (CK);
2. *Pedagogical Knowledge* (PK);
3. *Technological Knowledge* (TK);
4. *Pedagogical Content Knowledge* (PCK);
5. *Technological Content Knowledge* (TCK);
6. *Technological Pedagogical Knowledge* (TPK); dan
7. *Technological Pedagogical Content Knowledge* (TPCK)



Gambar 1. *Technological Pedagogical Content Knowledge Framework*
(<http://www.matt-koehler.com>)

TPCK is a form of knowledge covering three components: content, pedagogy and technology. TPCK includes pedagogical technique that makes use of technology in a constructive way to teach a content; what knowledge that makes a concept difficult or easy to be learned and how technology could help solve problems being faced by students; and knowledge of how technology could be utilized to develop the existing knowledge and to develop new epistemology or to threnghen the old one (Mishra and Koehler, 2006).

The Relationship between TPCK and KKNi in Strengthening the Competencies of Candidate Teachers

To meet the national criteria, teachers should undergo professionalization or the process towards continuous real professionalism. The development of the professionalism of teachers who have held educator certificates is performed to keep their professionalism up to date with the development of science, technology, arts and culture or sports (Danim, 2010). An effort for the qualification of university graduates in Indonesia is based up on the Government Regulation Number 8/2012 on KKNi which has become the reference in arranging the learning achievement of graduates in every level of national education. KKNi is expected to be able to change the way to value one's qualification, not only to consider the certificate but the qualification already agreed nationally as the basis of the recognition of the educational outcomes. Therefore, LPTK needs to be integrated with TPCK for the achievement of the teacher candidates.

One of the frameworks of knowledge that can develop teachers' competencies is Technological Pedagogical Content Knowledge Framework (TPCK). Through TPCK the teacher candidates not only have to develop their pedagogical knowledge or content knowledge but they are also expected to know how to present the teaching materials properly using technology so that the teaching and learning process can run effectively and efficiently. TPCK also matches teacher basic competency contained in the Government Regulation Number 14/2005 on Teachers and University Lecturers, i.e. pedagogical and professional competencies.

Pedagogical competence deals with pedagogical knowledge because they have similar characteristics; that is, the knowledge of students' characteristics, classroom management, lesson plan development, and its implementation, knowledge of strategy and learning models and evaluation. On the other hand, professional competence deals with content knowledge; namely, the knowledge of teaching materials. Both pedagogical and professional knowledge require teachers to use information technology and communication in the teaching and learning process or their self-development. Therefore, teachers need to possess technological knowledge.

To become professional teachers those competences can not stand alone but they should go hand in hand along with the three domains of teachers' knowledge so that the knowledge is integrated for teachers to do teaching effectively and efficiently. The goal of teacher professionalism is to create better and effective learning for students. Good learning can be achieved when students understand the materials being presented by the teacher. Here is the time when teachers play a key role in designing learning strategies that can give a positive effect to the students. Teachers need to actualize their knowledge and the competencies they possess in planning the strategies. TPCK is the answer to this. One of the forms of the application of TPCK in the teaching and learning is the use of technology in teaching certain materials. The integration of technology in teaching is deemed important as the answer to the advancement of information technology and communication. Technology can help teachers develop their professionalism through which they can access various teaching materials, teaching strategies in their areas of study.

Based on the Government Regulation on Teachers and University Lecturers, non-teaching graduates can get Teachers Professional Education Program (PPG) to develop their competencies in order to be able to compete globally. Therefore, College of Education (LPTK) as an organization being responsible for organizing academic and professional education programs needs to conduct a study related to the improvement of quality in education, among others by organizing the so called KKNi-Based-Learning Program and TPCK so that the graduates of LPTK especially Mathematics Education and Natural Science are ready to compete globally that suit the generic description of Level 6 and 7 of KKNi.

On the basis of the above circumstances, the researcher attempted to analyze the strengths of the KKNi-based-teacher candidate students of Biology study program concerning TPCK in an effort to improve the competency and the quality of LPTK graduates to achieve the vision and missions of the Directorate General of Higher Education.

2. RESEARCH METHOD

This research is a descriptive study using Cross Sectional Survey method. The instruments used to gather the data were a test, a set of questionnaire, and interview. Some 243 students were taken as the sample that came from 4 LPTKs within Riau province (University of Riau (UR), University of Lancang Kuining (UNILAK), Islamic University of Riau (UIR) and University of Pasir Pengaraian (UPP). The test was taken from the national written test for Teachers Professional Education (UTN PLPG-SM3T) which was developed accordingly. This competency test consisted of 60 items in the form of multiple choices with 4 options. The test form can be seen in Table 1 below:

Tabel 1. The item models of Biology Competency Test based on TPCK Components

No	Basic Competencies	Essential Indicators	Components of TPCK	Total of items
1	Understanding scientific work principle	<ul style="list-style-type: none"> a. Planning investigations on Biology by using scientific methods b. Using scientific methods to overcome problems on Biology c. Presenting research findings verbally or non-verbally d. Making and using laboratory equipments 	CK (1 item) TK (1 item) PK (3 items) TPK (1 item) TPCK (1 item)	7 items
2	Understanding learning materials on Biology for Senior High School	<ul style="list-style-type: none"> a. Understanding the basic concept of teaching materials on virus, bacteria, <i>protista</i> and fungus b. Understanding the basic concept of teching materials on virus, bacteria, <i>protista</i> and fungus c. Understanding the basic concept of teaching materials on the structure of of plants and animals cell functions The structure of plants and animals cell functions, and cell transportation mechanism The structure of plants/vertebrata animals cell functions, movement system/ blood circulation d. Understanding the basic concept of digestion/breathing system, excretion system, excretion system/body endurance, and reproduction system e. Understanding the basic concept of teaching materials on the growth and development of plants, metabolism, the structure of the function of genetic materials and heredity principles f. Understanding the basic concept of teaching materials on mutation, evolution and biotechnology. 	CK (10 items) TK (2 items) TCK (4 items) PCK (3 items) TPCK (2 items)	21 items
No	Basic Competency	Essential Indicators	TPCK Components	Total of Items
3	Mastering the academic	Understanding the nature of IPA learning (Biology)	PK (14 items) TPK (5 items)	24 items

	competencies of Biology subject for Senior High School		PCK (3 items) TPCK (2 items)	
4	Understanding the latest development of materials in Biology	Describing the development of materials in Biology that matches the development of Knowledge, Technology and Science (IPTEKS)	CK (1 item) TK (3 items) PK (1 item) TCK (2 items) TPCK (1 item)	8 items
Total of items				60 items

The items of this competency test came after an analysis in order to know the realibility of the items. Realibility means the score obtained by a person is the same when it is tested to another person with the same test in a different situation or a different test in similar or different situation. According to Chua (2006) realibility refers to the same score when the same measurement is repeated so that it can be said that the test is reliable. The score should be stable and consistent for high reliability.

The reliability of the competency test is determined through a discriminatory index, difficulty index and Kuder Richardson 20. In the first try out towards 45 students an analysis was performed using Anates program 4.0, and Kuder Richardson 20 was gained as much as 0,76. This means that the items of the competency test already developed could be applied in this study. The next analysis could become the basis to design and develop the product of learning program (teaching materials, students work sheet, media design and evaluation). The initial product that was developed was in the form of a competency test in order to know the materials which were not yet fully mastered by the candidate teachers as the development of the Work Book Product. The development analysis of the competency test instrument used Anates V4, then the analysis was used to revise the product and would be dessiminated in a national/international seminar.

3. FINDINGS AND DISCUSSION

3.1. Findings

a. Respondents' Profile

The respondents' profile of Biology Education Study Program in 4 LPTKs within Riau Province is shown in Table 2 below:

Tabel 2. The Total of Respondents of Competency Test for Candidate Teachers of Biology

No.	Program/University	Total of Respondents
1.	Bilyg Teachers Professional Program University of Riau	17
2.	Undergraduate Program (S1) University of Riau	41
3.	Undergraduate Program (S1) Islamic University of Riau	99
4.	Undergraduate Program (S1) University of Lancang Kuning	38
5.	Undergraduate Program (S1) University of Pasir	48
Total		243

Respondents were chosen based on some considerations. The sample for the PPG students of Riau University was taken using *Total Sampling* technique because the number of students was relatively small (17 students). Whereas the sample for the undergraduate students (S1) was prioritized on the eight semester students who had experienced in attending various lectures either in theoretical subjects or in practical ones such as Micro Teaching and Teaching Practice. Therefore, the proportion of the size of the sample for each university was no more than 50 % from the total population.

b. The Analisis of respondents' profile related to the use of technology

On the basis of the collected data, the profile of the students who became the respondents in this study is presented in Table 3. Table 3 shows that the female respondents outnumber the male respondents (87,2 %) while the percentage of male respondents is 12, 8%. Most of the respondents have taken a computer course on *Microsoft Office* especially *Microsoft Word* and only few of them used to attend *Adobe Photoshop* course (3 respondents), *Corel Draw* (1 respondent) and *AutoCad* (1 respondent). A large number of respondents have attended an English course, others used to attend other language courses such as German (1 respondent), a course in Music (1 respondent) and a course in Marine Science (1 respondent)

The application mostly used in teaching and learning process was *Microsoft Power Point*. A great number of respondents (82, 7%) said that *Microsoft Power Point* was used in teaching and learning process. The application used to process pictures was among others, *Adobe Photoshop*, *Photoscape*, *Windows Paint*, *Corel Draw*, *Visual Basic*, and *Adobe Illustrator*. Furthermore, the applications normally used to analyze data are among others, *Anates* and *SPSS*. Other applications used for the same purpose are *Microsoft Publishers* to design learning media in the form of simple posters, leaflet, and others. *Windows Movie Maker* is used to to edit videos that will be used as a learning media; *Windows Media Player*, *GOM Player*, and *Winamp* are used to play videos; *Mozilla Firefox* and *Chrome* are used as a browser for the Internet; *Youtube Downloader* and *Atube Catcher* are used as copy videos from webs especially *Youtube* that can be used as learning media; and *Macromedia Flash* that is used to design multi-media learning.

Tabel 3. The Analisis of Respondents' Profile

	PPG UR		SI UR		SI UIR		SI UNILAK		SI UPP		Total	
Jenis Kelamin												
Pria	3	17,6	7	17,1	12	12,1	2	5,3	7	14,6	31	12,8
Wanita	14	82,4	34	82,9	87	87,9	36	94,7	41	85,4	212	87,2
Kursus Komputer												
Pernah	1	5,9	12	29,3	26	26,3	9	23,7	18	37,5	66	27,2
Tidak Pernah	16	94,1	29	70,7	73	73,7	29	76,3	30	62,5	177	72,8
Kursus Lain												
Pernah	2	11,8	12	29,3	17	17,2	4	10,5	4	8,3	39	16,1
Tidak Pernah	15	88,2	29	70,7	82	82,8	34	89,5	44	91,7	204	83,9
Aplikasi komputer dalam pembelajaran												
Ms. Word	10	58,8	30	73,2	78	78,8	17	45,9	28	58,3	163	67,1
Ms. Excel	4	23,5	30	73,2	61	61,6	17	45,9	23	47,9	135	55,6
Ms. PowerPoint	15	88,2	38	92,7	88	88,9	18	48,6	42	87,5	201	82,7
Pengolah Gambar	2	11,8	21	51,2	14	14,1	2	5,4	3	6,3	42	17,3
Pengolah Angka	0	0,0	0	0,0	1	1,0	17	45,9	2	4,2	20	8,2
Lain-lain	6	35,3	24	58,5	27	27,3	3	8,1	8	16,7	68	28,0

c. The Analisis of Respondents' Profile Related to TPCK

Based on the data of the students' marks obtained from several subjects, i.e. Biology Learning Program Development (P3B), Teaching Practice (PPL 2), and other subjects related to technology and learning, i.e. University of Riau (UR) and University of Lancang Kuning (UNILAK) with Biomultimedia subject, Islamic University of Riau (UIR) with Media in Learning subject, University of Pasir Pengaraian (UPP) with Learning Innovation subject, on the whole the students already gained good achievement with the marks ranging from B to A. PPL 2 was the best of all with the average mark of 3, 96. It can also be seen from the average of the Commulation Achievement Index (IPK) of all subjects students had taken up which was 3,31 (Table 4).

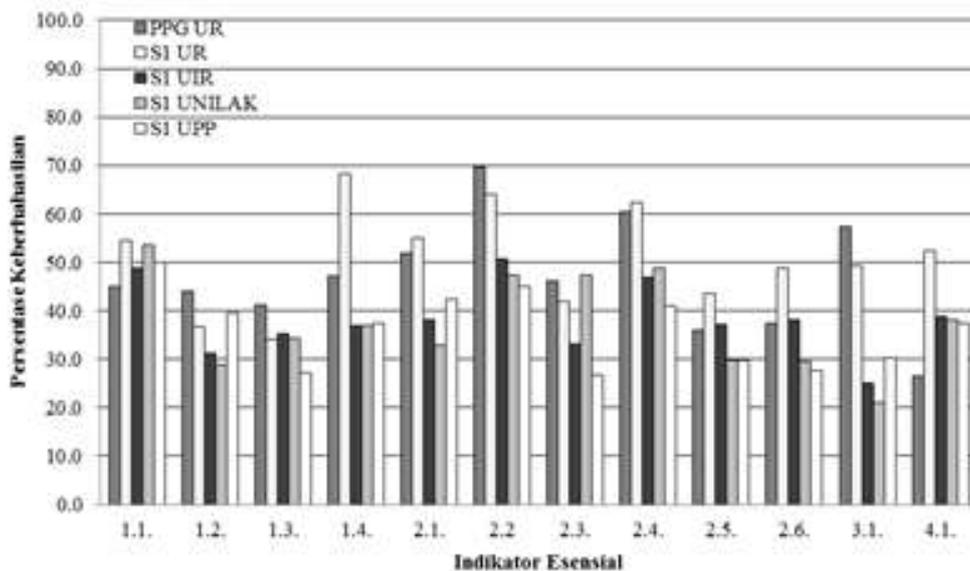
Tabel 4. Respondents' Academic Profile

	PPG UR	SI UR	SI UIR	SI UNILAK	SI UPP	Total
Rerata Nilai						
Biomultimedia	3,38	3,60	3,88	3,61	3,46	3,67
P3B	3,26	3,75	3,48	-	3,52	3,53
PPL 1	3,57	3,63	3,17	-	3,46	3,36
PPL 2	3,93	3,98	3,98	-	3,90	3,96
Rerata IPK	3,32	3,35	3,16	3,61	3,35	3,31

On the basis of the respondents' profile, it is expected that the students have possessed the competences of pedagogy, content and technology.

d. The Results of Biology Competency Test

The Biology competency test was held towards 233 students from 4 LPTKs in Riau province (Table 2). Based on the collected data, the students' achievement profile in completing the Biology competency test based on essential indicators are presented in Figure 2 and Table 5.



Figurw 2. Students' Profile in Completing the Biology Competency Test

Tabel 5. The Percentages of the Biology Competency Test Based on Essential Indicators

Indikator Esensial	PPG UR	SI UR	SI UIR	SI UNILAK	SI UPP	Rerata
1.1.	45,1	54,5	48,8	53,5	50,0	50,5
1.2.	44,1	36,6	31,3	28,9	39,6	34,4
1.3.	41,2	34,1	35,4	34,2	27,1	33,7
1.4.	47,1	68,3	36,9	36,8	37,5	43,0
2.1.	52,0	54,9	38,0	32,9	42,4	41,9
2.2.	69,7	64,1	50,6	47,4	44,9	52,6
2.3.	46,2	41,8	33,2	47,4	26,8	36,5
2.4.	60,5	62,4	46,9	48,9	41,1	49,6
2.5.	35,9	43,7	37,1	29,7	29,8	35,5
2.6.	37,5	48,8	38,0	29,6	27,6	36,4
3.1.	57,4	49,4	25,0	21,1	30,2	31,8
4.1.	26,5	52,4	38,9	38,2	37,5	39,9
Rerata	48,1%	51,3%	39,2%	37,6%	35,3%	40,8%

Based on Table 6 it is discovered that for Indicators 1.1. Planning an investigation in Biology using a scientific method, on the whole 50% has been achieved; As of Indicator 1.2. Using a scientific method to overcome biological problems, no respondent obtains 50 % with the average of 34,4 %. Similarly, Indicator 1.3. Displaying the results of investigation in Biology verbally or non-verbally (graphs, tables, diagrams), only 33,7 % is achieved. For Indicator 1.4. Making and using laboratory equipments, on the whole. the average of 43,0 % is achieved where the highest achievement is obtained by the students of UIR with the percentage of 68,3 %, whereas others are under under 50 %.

As of Indicator 2.1. Understanding the basic concept of teaching materials on virus, bacteria, *protista* and fungus, 41,9 % is achieved where the highest achievement is gained by Riau University (UR) students (54,9 %), followed by students of PPG UR (52 %). Furthermore, Indicator 2.2. Understanding the basic teaching materials on biological variety, the world of animals and plants, ecosystem and environmental pollution, 52,6 % is reached where the highest achievement is obtained by the students of PPG UR (69,7 %). Unlike Indicator 2.2., Indicator 2.3. Understanding the basic concept of teaching materials on the structure of plants and animals cell functions, cell transportation mechanism, the structure of plants cells/vertebrata animals cell functions, movement/blood circulation only reached 36,5 % which is relatively low. On the whole. for Indicator 2.4. Understanding the basic concept of teaching materials on digestion/breathing system, excretion system, excretion/body endurance, reproduction system, the achievement is 49,1 % where the highest result is gained by the students of UR (62,4 %) followed by the students of PPG UR (60,5 %). For Indicator 2.5. Understanding the basic concept of teaching materials on the growth and development of plants, metabolism, the structure of genetic material functions, heredity principle and Indicator 2.6. Understanding the basic concept of teaching materials on mutation, evolution, and biotechnology, the students' ability to answer the question items of both indicators is relatively low with the achievement of 35,5 % and 36, 4 % respectively.

For Indicator 3.1. Understanding the assense of learning Biology, on the whole the students achievement is relatively low (31, 8%) ; however, the students of PPG UR had reached 57, 4 % which is the highest percentage, Both UNILAK and UIR students get the lowest percentages (21, 1 % and 25,0 %).

On the basis of Figure 2. there is a big difference between the students' achievement in answering the question items in the essential indicators 3.1. and 1.4. For Indicator 3.1. the students of PPG Biology Study Program get the achievement of more than 50 % that is 57, 4% (Table 4), while the undergraduate students could only gain below 50%. The students of UIR and UNILAK were in the lowest percentage. i.e, 25,5 % and 21,1 % respectively (Table 4). Indicator 1.4. that describes the development of materials in Biology based on the development of IPTEKS, the highest achievement is gained by UR students with the percentage of 68, 3% (Table 4), whereas other students could only gain below 50 %.

e. The *Prototype of lesson design and workbooks*

Based on the analysis of the respondents' profiles (needs assessment) and the analysis of the Biology competency test data, a learning design will be integrated in the KKNI-based curriculum of undergraduate (S1) students majoring in Biology. Therefore, the materials that are expected to be integrated in some subjects are required. The next step is analyzing several subjects that can be categorized into TPCK so that KKNI-based-workbooks can be designed based on TPCK or they can strengthen TPCK as displayed in Figure 3.

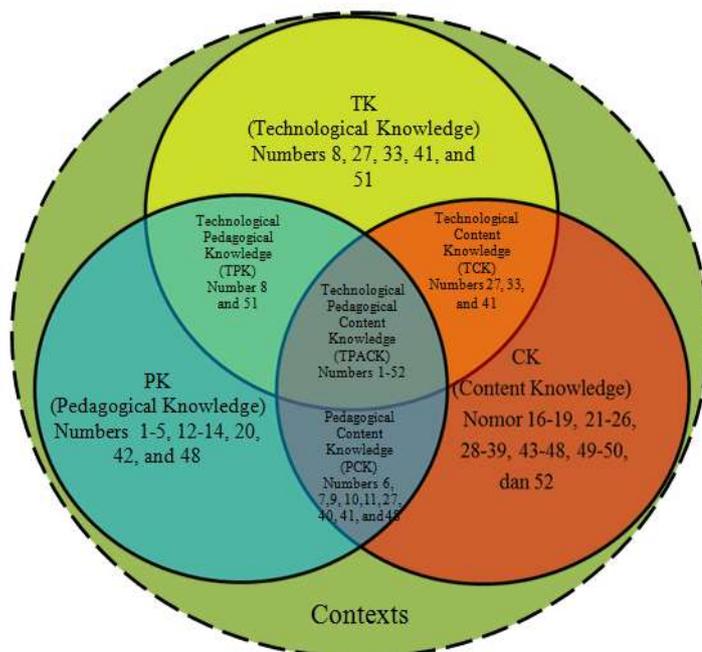


Figure 3. The relationships between the subject family and TPACK

Description :

<p>Foundation of Education subject (MKDK) / Pedagogy</p> <ol style="list-style-type: none"> 1. Educational Foundation 2. Learners Development 3. Educational Management 4. Guidance dan Counseling 5. Teacher Professional Development <p>Skill subjects and Learning Process (MKKPP) / Pedagogy</p> <ol style="list-style-type: none"> 6. Curriculum Analysis dan Lesson Plan in Biology 7. Learning Strategies in Biology 8. Learning Media in Biology 9. Learning Assessment in Biology 10. Teaching Practice in Biology 11. An Introduction to School Environment <p>Educational Development Subject (MKPP) / Pedagogy</p> <ol style="list-style-type: none"> 12. Educational Innovation 13. Educational Reserach 14. Educational Statistics 15. Thesis <p>Skill Subjects (MKBK) Elective/ Pedagogy dan Content</p> <ol style="list-style-type: none"> 43. Mangrove Ecosystem Management 44. Plants Ecofisiology 45. Animals Ecofisiology 46. Analytical Microbiology 47. Micology 48. Problems in Biology Education 49. Environmental Impacts Analysis 50. Endocrinology 51. Biomultimedia 52. Biomanajement 	<p>Skill Subjects (MKBK) Compulsory / Content</p> <ol style="list-style-type: none"> 16. Basic Mathematics 17. Basic Biology 18. Basic Chemistry 19. Basic Physics 20. Foundations of MIPA Education 21. IPA for Junior High School (SMP) 22. Technique and Laboratory Management 23. Plants Development Strucure 24. Sistematika Tumbuhan Rendah 25. Sistematika Invertebrata 26. Animals Development Structure 27. Scientific Writing 28. Basic Microbiology 29. Sistematika Tumbuhan Tinggi 30. Cell Biologyl 31. Biochemistry 32. Sistematika Vertebrata 33. Genetics and Evolution 34. Biotechnology 35. Plants Fisiology 36. Animals Fisiology 37. Ecology 38. Marine Ecology 39. Biology for Senior High School (SMA) 40. English for Biology 41. Seminar on Biology 42. Bioetnomelayu
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Materials for Mathematics Education and Natural Science based on KKNi and the TOCK approach was produced. The workbooks consist of three parts, i.e. Introduction (Part1), Teachers Competencies (Part II) and Workbooks (Part III). The produced workbooks contain six learning activities as described below:

The Framework of the Development of Workbooks

Part I

a. The Description of the Workbooks

- What and why the Workbooks are developed
- The purpose and the benefits of the Workbooks
- The target of the users

b. Learning guide

Part II

a. The competencies of professional teachers

- Pedagogy
- Professional
- Attitude
- Personality

b. The relationship between TPCK and KKNi to produce professional teachers

c. Competency item models that should be mastered by Biology candidate teachers

Part III

The Strengthening of TPCK Biology Class per-indicator
The description and application per-indicator
1. <i>Concept map</i>
2. Summary of theory (content)
3. Websites of material learning (technology)
4. What teachers need to do (pedagogy)
5. Models of work sheet
6. Exercise
7. Evaluation
8. Reflection

3.2. Discussion

From the data analysis of the respondents' profile, the outputs in the form of characteristics or profile of the candidate teachers of Mathematics Education and Natural Science subjects (PMIPA) were known. The data analysis indicated that there was a tight competition between the graduates of PMIPA and FMIPA who wanted to become teachers when judging from their competencies. The researcher has designed and developed workbooks in order to improve the competency of the candidate PMIPA teachers and a detailed job analysis have been made based on the need. This analysis stage took a considerable time as the limitations found in this stage would give a great impression and effect to the product that would be produced in the stage of writing the workbooks as well as awaiting the response of the students when the evaluation was being made. Therefore, at this stage the researcher explained that there were a number of things to be analyzed. For the analysis stage the researcher had performed needs analysis such as documentation analysis, questionnaire analysis and the results of Biology Competency test at 4 LPTKs in Riau province (University of Riau, Islamic University of Riau, University of Lancang Kuning and University of Pasir Pengaraian).

Through the results of Biology Competency Test analysis it was discovered that the competency of Biology teacher candidates was still low because only few of them could reach the achievement percentage over 50 % where the highest average achievement percentage (51,3%) was achieved by the students of Riau University. It was also found out that the indicators that gained the lowest achievement were respectively, Indicator 1.2. Using scientific methods to solve Biology problems; Indicator 1.3. Presenting the results of investigation in Biology verbally or non-verbally

(graphs, tables, diagrams); and Indicator 3.1. Understanding the nature of IPA learning in Biology. Meanwhile, the highest achievement was obtained through Indicator 2.2. Understanding the basic concept of teaching materials on the variety of biological things, animals and plants world, ecosystem and environmental contamination; 1.1. Planning an investigation in Biology using scientific methods; and 2.4. Understanding the basic concept of teaching materials on digestion/ breathing system, excretion system, excretion/ body endurance system and reproduction system.

Other analyses showed that there was a big difference of students' achievement in answering the questions; namely, in the essential indicator 3.1. and 1.4. As of Indicator 3.1. Understanding the nature of IPA learning (Biology) the students of PPG Biology of Riau University got the achievement of more than 50 % that was 57, 4 %, whereas the undergraduate students only gained below 50 %.

With regard to the answers to the questionnaire and interview it was proved that students had possessed other skills other than the content competency, i.e. computer course that was taken by the majority of the respondents such as *Microsoft Office* especially *Microsoft Word*. Few of them attended *Adobe Photoshop* course (3 respondents), *Corel Draw* (1 respondent), and *AutoCad* (1 respondent). Most of the respondents said that they had already taken English courses, a language course in German (1 respondent) a course in Music (1 respondent) and a course in Marine Science (1 respondent). In addition, the PMIPA candidate teachers had low competency in content knowledge (40,8%) and still not many of them realized the importance of other competencies such as the ability to use technology and language which could enable them to understand the learning materials more easily.

In general, the data analysis has produced a plan or design that will be followed up in the next study. That design is in the form of KKNi and TPCK-based-Lesson Plans and Workbooks. Lesson Plan in particular is a very important factor in teaching and learning process which must be chronological, logic and rational aiming at solving problems (Akhiar & Shamsina, 2010). A teacher should plan her teaching before going into the class just the same as a researcher who will make a product design before he uses it in his study.

Learning design can be seen from a number of perspectives, among others, as a discipline, as a science, as a system or as a process. As a discipline learning design is a branch of science relating to the study or theory of learning strategies. It is also a process to develop and apply the strategies that involve approaches, rules, teaching techniques and learning. As a science, learning design is a branch of science that results in detailed specifications to develop, implement, evaluate and create the situation that can ease the learning of big units (macro scale) and smaller units (micro scale) of subjects at all levels. The effectiveness of the specifications will be tested and analyzed in the teaching and learning process. As a system, on the other hand, learning design is a process seen from the systematic development of learning specifications that use learning and design theories to ensure the quality of learning. This is a process of analyzing learning needs, goals and the development of delivery system. This process covers materials development and the results of learning activities.

In addition, learning design as a process according to Syaiful Sagala (2005) is developing teaching systematically using specific learning theories to ensure the quality of learning. This statement means that learning design should be suited to the educational and learning concepts contained in the curriculum. Therefore, it could be concluded that it is very important for a researcher or a teacher to develop instructional modules.

The workbooks to be developed are workbooks for Science in Education (IPA Biology) based on KKNi with TPCK approach. The workbooks are very relevant with the latest issues such as the provision of professional teachers with competences. The workbooks are very useful because they contain clear and accurate competency standards based on KKNi with TPCK approach for Biology study program. It is expected that the Biology candidate teachers master all the competencies so that they can compete with other graduates from other faculties or study programs. Mishra and Koehler (2006) state that TPCK consists of three components: content, pedagogy, and technology. It plays a key role in improving the quality of learning as the three components are closely related to each other. Pedagogy makes use of technology constructively to teach a certain material so that students are helped to understand the lesson and to solve the problems they have through making use of technology in the teaching and learning process.

Technology can also be used to enrich the existing knowledge and develop new epistemology or to strengthen the old one. Loughran (2014) added that the pedagogy the teachers put into practice is expected to enable learning culture by which students can study and develop themselves through experience provided by the teacher during the teaching and learning process.

The teaching and learning process is not only restricted to the relationship between teachers and students but a complex process that is focused on preparing students to become competent persons. Therefore, teachers should support, supervise and guide students to achieve the desired competencies (Goodwin et al., 2014). Williams added that there are three teacher essential dimensions in the teaching and learning process; that is, (1) managing the teachers conception relating to personal identity, (2) identifying the perspective change related to the teaching and learning process, (3) negotiating complex professional relationships associated with learning. These three dimensions explain the teachers' ability in understanding pedagogical components. Loughran (2014) describes that there are several things that teachers should do to become professional teachers and all of them are the marriage of some aspects that can clearly be seen in Figure 4.

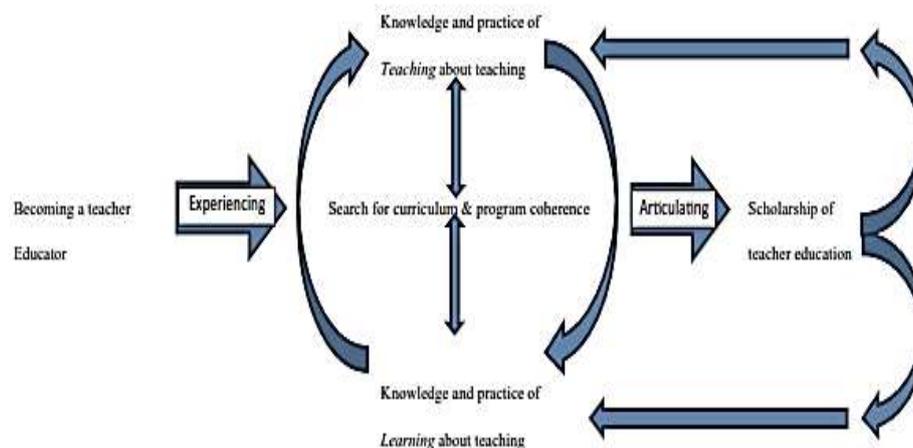


Figure 4. The road to become a professional teacher (Loughran, 2014)

Figure 4 describes the road to become a professional teacher. The development or enrichment of knowledge and pedagogy is closely related to the teacher's understanding of himself as an educator, challenges and expectations of stakeholders and the institutions that produce professional teachers. König (2013) in his study that focused on general pedagogical knowledge (GPK) states that to produce professional teachers, there must be an intensive development associated with teachers competencies. Kellner, et al (2011) argue that PCK is very important to be developed because it is a unique study on the teaching profession that has not yet developed in the candidate teachers. Halai (2012) in his research findings stated in detail that teachers should develop three areas in the teaching and learning process, i.e. subject matter knowledge, pedagogical knowledge, and pedagogical content.

PCK can be developed in a number of ways, among others by using PBL (McConnell, 2013) being associated with some components of pedagogy, content and knowledge (PCK); that is, content, investigation-based-pedagogy, students learning assessment, knowledge, and experience in classroom management and the strategy that could create productive learning communities. A study conducted by Sancar Tokmak, et al. (2014) found out that the TPACK of candidate teachers had developed after the application of a learning strategy that produced digital stories. It was concluded that teachers and teachers to be are the the first individuals who could shape students character, provide students with knowledge and skills and master TPACK. Therefore, through the KKNi and TPACK-based-Lesson Plan and Workbooks it is expected that the desired competencies could be possessed by teachers and teachers to be.

3. CONCLUSIONS

This study concluded that the competency of the candidate teachers was still low in terms of the aspects of content and technology although it was already good enough in terms of pedagogy. Therefore, the KKNi and TPCK-based-Lesson Plan and Workbooks are badly needed in order for the LPTK graduates to be able to improve their competencies and the ability to compete and to support the vision and missions of the Directorate General of Higher Education. What's more, LPTK especially Faculty of Education is expected to be able to produce educated people with good character, being smart, skillful and highly competitive in order to develop Indonesian citizens who possess outstanding capability and competencies in order to create prosperity, security, welfare and justice.

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