Building the pre-service biology teachers’ capability through the reconstruction of life-based learning curriculum

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Abstract. The 21st-century education is a medium of transformation through which learners are encouraged to become a creative thinker, lifelong learner, and leader of change. The curriculum of biology education program should be developed in line with the goal of national education, the direction of the 21st-century education, and the core concepts and core competencies of biology. The national education goal which is similar to the demands of the 21st century learning has become the foundation for the development of Indonesian future generations who are expected to honor the ideology of Pancasila and morality, to be healthy, knowledgeable, capable, creative, independent, democratic, and responsible as a citizen. Biology education program contains lessons that can prepare future generations to take role in sustainable development and in solving global social problems. The curriculum of biology teacher training program can be developed through the redefinition of the 21st-century education goal that is to equip biology teachers with four competencies and capability features by integrating mastery content, attitudes, characters, values, managerial skills, problem-solving practices and research skills. However, the reconstruction of learning and assessment procedures is still a major issue in curriculum development. Therefore, life-based learning curriculum can an alternative to embed learning to a meaningful real world context where students are required to study authentic issues, solve realistic problems or do a project with a set of practical goals.

1. Introduction

The 21st century can be characterized as an era where knowledge rests in biology advancement [7]. According to the Committee on a New Biology for the 21st Century, biology is able to provide a solution to the needs of the society in four major aspects: sustainable food production, environment protection, renewable energy provision, and the development of human health quality [5]. Biology, thus, has an important position and becomes an essential part of the growth of future generations who are prepared to play a role in solving social issues.

Biology education study program is a program which provides training for the pre-service biology teachers. The aim of this program should be adjusted to the goal of national education, the objective of the 21st century education, and the main purpose of biology education. National education has a purpose to strengthen the capability of Indonesian generations as a whole human being who is inspired by Pancasila, who has a noble character, perfect health, creativity, excellent knowledge and skills, a sense of independence, democracy and responsibility. The purpose of national education is more likely to resemble the goal of the 21st century education which is to serve as a medium of transformation for
learners to develop to be a creative thinker, long life learner, and leader of change in the Industrial Revolution 4.0 era.

Biology should prepare future generations to be able to take a significant role in sustainable development and solving global social problems. The main objectives of biology at the school level, therefore, should be reformulated as follows: 1) to shape learners’ positive attitudes towards their identity as part of the universe so that every student can glorify God’s greatness, 2) to make learners realize that they take part in sustaining earth ecosystems, 3) to develop learners’ scientific attitudes as a critical, creative, and innovative citizen, 4) to promote learners’ ability to work in scientific fields, propose and test hypotheses through an experiment, and communicate the results in either an oral or a written form, 5) to grow learners’ scientific, analytic, inductive, and deductive thinking abilities using biology concepts and principles, 6) to develop learners’ mastery of biology concepts and principles and the linkages in both sub-disciplinary or interdisciplinary biology, (7) to make learners able to apply biology concepts and principles in finding a useful creation to fulfill human needs.

The curriculum of pre-service biology teacher education can be developed through a redefinition of the aim of biology teacher education in the 21st century which is to equip the teacher with four competences and capability features by integrating content mastery, attitudes, characters, values, managerial skills, problem solving practices and research skills. The main problem in developing the curriculum is a reformation of learning procedures and assessment that should be directed to scientific learning which is student-centered and based on science philosophy and socio-scientific issues and the 21st century education goal. The 21st century education aims to provide students with the 21st century skills. Partnership for 21st Century Skill and The National Science Teachers Association (NSTA) explain that the 21st century skills include creativity and innovation, critical thinking and problem solving skills, flexibility and adaption skills, initiative and self-direction skills, cross-cultural skills, productivity and accountability, leadership and responsibility, and literacy skills (communication skills, collaborative skills, information, media, and information and communication literacy skills).

Teacher training institutions are higher education institutions that carry on a mission to produce excellent educators who can perform learning tasks and manage education based on technological pedagogical content knowledge (TPACK). The reconstruction of the curriculum of biology teacher training education, therefore, should be focused on the creation of graduates who are capable to keep up with the development of the 21st century science and technology (Capability and Life-based Learning curriculum).

2. Methods
The development of the curriculum of biology teacher training education was designed bottom-up such as suggested by [2]. This study also involved the members of the biology faculty and biology teachers. An interview was conducted to the officials from the department of education to collect suggestions on the management of the curriculum and support for biology teachers.

2.1. Phase I. Review of the Internal Curriculum
The first phase was begun with reviewing the curriculum that was currently used in the biology education program of Universitas Negeri Malang. An analysis was conducted to the curriculum goals, the implementation process, learning process, and learning assessment. An invitation was sent to the alumni who were already working as a teacher or staff in the department of education or other educational institutions to evaluate the compatibility of the curriculum with the school condition. Some experts were also invited to analyze the curriculum and the results showed that this curriculum had to be reconstructed in order to conform with the requirements of biology education and development in the 21st century.

2.2. Phase II. Development of a Curriculum Draft
The development of a curriculum draft was performed together with the curriculum taskforce from the biology education study program, Universitas Negeri Malang. In the first place, the draft was reviewed
by the teaching staff from the Biology Department of Universitas Negeri Malang. In particular, this study involved the members of the faculty to examine whether the main concepts of Vision and Change In Undergraduate Biology Education, A Call To Action [1], the Biological Curriculum Framework of KOBI (the Biology Consortium of Indonesian), and the framework of the biology education curriculum from the Association of Indonesian Biology Education Study Program (APSPBI) had become the foundation of the curriculum development. Through a focus group discussion, the harmony between the concepts was confirmed and was all set to develop a framework of a curriculum that could be implemented in the biology education program.

2.3. Phase III. Review and Validation
At the third phase of the development of the curriculum, feedback on the initial draft was collected from some biology and biology education professors from various national institutions who had an expertise in different sub-disciplines. They were asked to evaluate every statement and provide feedback related to: 1) the accuracy, and 2) the importance of skills that should be mastered by the graduates.

2.4. Phase IV. Dissemination
The activities carried out in the fourth phase are:
- Socialization: to open stakeholder knowledge and understanding of the new curriculum
- Lecture preparation: prepares the lecturer to understand the philosophy of the new curriculum, new teaching procedures, and new rules relating to the implementation of the new curriculum
- Lecturer capacity building: providing lecturer training in designing lesson plans and lecture systems
- Implementation: curriculum implementation includes the preparation of lectures, assessment, system administration, learning management system
- Monitoring and evaluation: monitoring and evaluation of all curriculum components and stages of curriculum implementation.

3. Results And Discussion

3.1. The Biology Education Graduates Profiles
The biology education study program of the Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang (UM) has been developed as a study program that can produce excellent graduates who are competent as a biology educator and who are well prepared to join the teacher professional program to become a professional teacher. The graduates are expected to be equipped with the skills to manage biology/science laboratories at schools and the ability to implement the skills to support their role as a teacher. The graduates should also be provided with a research ability that may help them to encounter the developing world of biology education research and an entrepreneurship ability that can assist those who want to become an entrepreneur in the education field.

The curriculum applied in the biology education study program was developed in line with the biology advancement, the requirements of the 21st century education, and school needs. According to the Decree of the Minister of Research and Technology (Permenristekdikti) 44/2015, curriculum refers to a set of plans and arrangements of the graduates learning goals, materials, processes, and assessment that can be used as guidance to run a study program. Curriculum reconstruction should cover the arrangement of graduates learning outcomes, subjects description, courses plans, learning strategies, formative and summative assessment which is educative and authentic.

The biology education study program graduates should bring the spirit of Pancasila, putting forward aspirations by developing concerns with the foster-nurture principle, promoting the ability to implement their knowledge to organize the 21st century biology learning at senior high schools (SMA), vocational high schools (SMK), or Islamic high schools (MA), manage school laboratory, find a creative and innovative solution to problems in biology, conduct a research in biology education,
produce a national-level creation in biology learning, and become an entrepreneur and life long learner.

3.2. Learning Goals of the Graduates
According to the Decree of the Minister of Research and Technology (Permenristekdikti) No. 44/2015, learning goals of the graduates fall into two categories, attitudes and skills. These learning goals have been formulated based on research findings. Data of the research was gathered through an interview and a questionnaire distributed to the members of the biology and biology education faculties, and the alumni. The results showed that the graduates of these faculties or the pre-service biology teachers had possessed the competencies of science and biology basic concepts. These concepts provide a foundation for the graduates to work in the scientific field and to extend their biology expertise. The first year students are required to be able to understand basic science which provides a basis for scientific work and thinking (Table 1). The freshmen also have started recognizing biology science that will be further enhanced in the second year. The goal of the second year biology education is to master biology knowledge through thinking processes and scientific work that involves inquiry and discovery. Basic science knowledge and basic biology concepts are obtained from the study program; therefore, the program needs to prepare learning tools that could meet the goals.

| Table 1. Learning Goals of The First Year and the Second Year Pre-service Biology Teachers |
| Level | Science Features | Learning Goals | Content |
|-------|-----------------|----------------|---------|
| Year I | Basic Science | To understand basic science which becomes a foundation of scientific work and scientific thinking in biology | Science philosophy, scientific thinking, scientific work, physics, chemistry, basic biology, mathematics, and statistics |
| Year II | Fundamental of Biology | To master biology knowledge through thinking processes and scientific work which involves inquiry and discovery stages. | Cell biology, biodiversity, structure and function, genetics, evolution, and ecology |

3.3. Pedagogical Objectives
The third year students are introduced to more profound biology concepts and biology education practices and pedagogy. Experts in biology education suggest that biology pedagogical objectives should refer to the Decree of the Minister of National Education (Permendiknas) No. 16/2007 on the academic qualification standards and teacher competencies. Therefore, the pedagogical objectives in biology education can be described in details as follows (Table 2).

| Table 2. Pedagogical Objectives |
| Pedagogical Objectives |
| 1 | To master the philosophy of education, the psychology of learning, learners development, learning and theories of learning |
| 2 | To understand the concepts, principles, and research methods in biology education |
| 3 | To analyze biology curriculum of middle schools through curriculum analysis in order to produce indicators, learning materials, assessment instruments, learning strategies and media which are suitable with the applicable curriculum |
| 4 | To understand the philosophy, approaches, methods, media, and evaluation processes in biology learning which are oriented to the future, based on digital era life skills, local potentials and local wisdom |
| 5 | To be able to implement the mastery of biology concepts and educational sciences in designing a learning which can facilitate students’ active participation and develop students’ potentials by utilizing the development of science and technology and referring to the national education standards, classroom and school problems, learners development, and the characteristics of the
environment

6 To be able to implement the mastery of biology concepts and educational sciences in educating learners who are able to achieve the educational goals and actualize their potentials by utilizing the development of science and technology and referring to the national education standards, classroom and school problems, learners development, and the characteristics of the environment

7 To be able to implement the mastery of biology concepts and educational sciences in conducting sustainable process and product assessment systematically by utilizing the development of science and technology and referring to the national education standards, classroom and school problems, learners development, and the characteristics of the environment to collect meaningful information for decision making

8 To master the management and the utilization of biology/science laboratory at schools

3.4. Professional Development Competencies

Sustainable professional development is the development of teacher’s competency which is conducted gradually and continuously to improve the teacher’s professionalism. Teacher professional development activities include self improvement, scientific publication, and/or innovative work development. Learning goals related to the professional development of the graduates are presented in Table 3.

| Professional Development Competencies |
|--------------------------------------|
| • To be able to implement the mastery of biology concepts and educational sciences in designing a learning with a particular focus, applying the plan, and evaluating the result |
| • To be able to teach biology and implement technological pedagogical content knowledge (TPACK) concepts |
| • To be able to make a decision on learner’s achievement, provide feedback and report the result based on assessment data analysis |
| • To be able to make a decision on the improvement of biology learning in the classroom in particular and at school in general based on the results of planning, implementation, and reflection of learning which are conducted individually or collaboratively |
| • To be responsible for their tasks as a teacher and to show high work ethics and responsibility, confidence as an educator and to be able to communicate effectively based on teacher’s code of ethics, either in the classroom in particular, or at school and in the society in general |
| • To be able to solve problems in biology education through research by utilizing the development of science and technology and referring to the school context and learners’ development |
| • To be able to communicate research findings and problem solving ideas in biology education using technology and information which is based on the development of science and technology |
| • To apply the management and entrepreneurship principles in the biology based industrial world |

3.5. The 21st Century Skills

Balancing the 21st century education demands with the needs of the 21st century learners is the major problem faced by teachers in every educational institution nowadays. The 21st century learning is focused mainly on the idea that students put a better interest in what they see around them, such as social issues, activities, work, technology and daily needs. Students are more motivated to learn the most recent concepts and skills rather than to learn concepts and skills that mostly came in handy in the past. Students are willing to discuss relevant topics so that they feel more prepared to succeed in different situations and outside the academic world.
Table 4. The 21st Century Skills

| Other Capability-based Learning Goals CP |
|------------------------------------------|
| Spirituality:                            |
| Have faith in God and able to show religious attitudes |
| Characters:                              |
| • Understand and perform national characters |
| • Able to be a source of learning         |
| Global awareness:                        |
| Pay attention to the biodiversity conservation |
| Laboratory skills:                       |
| Skillful in making use of software and hardware to work in the biology scientific field |
| The 21st century literacy skills:        |
| a) Life skills and career skills;        |
| b) Critical thinking, communication, collaboration, creativity |
| c) Information, media, and technology literate |
| Research skills:                         |
| • Understand and able to implement scientific methods through research findings and hypotheses testing |
| • Internalize academic values, norms, and ethics |
| Educator Code of Ethics:                 |
| Internalize educator code of ethics       |
| Self and institutional management skills: |
| Be independently responsible for the tasks within the expertise and for the organization achievement |

3.6. Student-Centered Learning: Life-based Learning Instruction

Life-based learning can be defined as the integration of learning into the meaningful real life contexts. The idea of life-based learning is perhaps similar to authentic learning (Iucu & Marin, 2014) or real-life based learning (Jonassen, Howland, Marra, & Crismond, 2008). In life-based learning, students are encouraged to study authentic issue, solve realistic problems or do a project with practical goals, and have an opportunity to investigate and talk about problems and projects that are applicable to their lives (Carlson, 2002). Life-based learning is designed based on four authentic learning principles: (1) focusing on practical problems, such as to resemble what the experts do in the field and communicate the results to the individuals met outside the classroom; (2) conducting investigation-based learning by putting an emphasis on metacognitive skills; (3) encouraging learners to participate in active interaction within their social learning environment, and 4) enabling students to make a choice and to direct their own learning to meaningful work and tasks (e-Teaching, 2016). Therefore, it is recommended for a teacher training program to (1) motivate students to design their own activities similar to those performed by a professional teacher in the field, (2) provide complex, ambiguous, and various challenges that need further investigation, (3) encourage the occurrence of self reflection, self assessment, and performance review, (4) motivate students to measure their own success and be responsible to achieve the goals set by the practitioners in the real work conditions, (5) motivate students to perform teamwork such as what happens in the workplace nowadays, (6) encourage
students to use various learning resources, and (7) help students to develop negotiation skills from different perspectives—including from the stakeholders’ perspectives.

Teacher plays various roles in the life-based curriculum. Teacher could be the provider of the learning resources, the instructor, the developer of the operational curriculum, the facilitator, or the catalyst of change who has strong commitment to keep bringing changes.

Life-based learning strategies are divided into two levels, individual learning and society-based learning. Individual learning strategies include all learning strategies that could facilitate students’ personal learning plans. A portfolio, for example, is the best way to monitor students’ learning progress. The society-based learning strategies aim to introduce students to the society life in which cooperation, teamwork, and positive dependence are established.

The path to life-based learning itself is managed by the 21st century skills such as critical thinking skills, problem-solving skills, scientific work skills, research skills, presentation skills, and public communication skills. Teacher needs to prioritize authentic issues so that students realize the relevance and meaningfulness of the lesson. Students can also apply knowledge with proper ways such as those used by the professionals.

An effective life-based learning can prepare preservice biology teachers to master three professional competencies: subject matter content knowledge; pedagogical knowledge; and pedagogical content knowledge (Zhang, 2015). Biology teachers have to understand biology content and pedagogical content so that they can help students with their problems. Professional science teachers who possess good mastery of the subjects will be able to select essential content to be taught to students. Teacher who have good pedagogical content are also able to promote students’ higher order critical thinking skills. On the other hand, teachers who are lacking in content knowledge and pedagogical content will find difficulties in promoting active learning. These teachers typically use repetition and memorization learning strategies in the classroom (Johnston &htee, 2006).

The 21st century teachers need to master not only the pedagogical content knowledge (PCK) skills but also the technological pedagogical content knowledge (TPACK). The TPACK framework was developed by (Koehler, Mishra, & Cain, 2013) by integrating technological knowledge to PCK. According to Koehler & Mishra (2009), “TK is knowledge about certain ways of thinking about, and working with technology, tools and resources, ... including information and communication technology”. The development of the teachers’ TPACK skills is very crucial in a technology-based teaching context. Thus, a biology teacher training program should:

- adjust the biology content and pedagogical content with the needs of the 21st century learners;
- adjust the biology content and pedagogical content with the recently applied technology;
- adjust learning with the 21st century learning standards and skills;
- implement direct learning strategies which are oriented to the mastery of knowledge through project learning and creativity development;
- use various assessment strategies to evaluate students’ performance (including formative assessment/assessment for learning, portfolios, and summative assessment);
- encourage learners to actively participate in learning communities;
- use various strategies to serve students from different backgrounds and create a differentiated learning environment;
- motivate students to become a lifelong learner.

4. Conclusion
The 21st century biology teacher education is a medium of transformation through which learners are encouraged to become a creative thinker, lifelong learner, and leader of change. The curriculum implemented in the biology teacher training program should be developed based on the goal of national education, the objective of the 21st century learning, and the core concepts and core competencies of biology. In life-based curriculum, learning is embedded into the meaningful real life contexts and students are required to reflect on authentic issues, solve practical problems or do a
project with a realistic goal. The students are actively involved in an investigation, discussion, and project that will be useful for them and their lives.

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