

## Development of Teaching Materials by Using Thinking Map on Embryology Learning

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**Abstract**—The purpose of this study is to develop learning materials by using thinking map in integrative learning model. The research method is educational design research which consist of three stages of preliminary, prototyping and assessment. The data obtained with the validation and test of learning result were analyzed by descriptive statistics. The study participants were 69 students and 3 experts. The result of preliminary research shows that there is diversity of student characteristic in Embryology learning. The teaching material prototype uses a thinking map designed and validated by 3 experts with a valid average result. The results of the implementation test show that the achievement of student learning outcomes on embryology learning with good average value. These results show that the designed prototype matches expectations with the results found. These results also show that the designed product has good internal relevance and consistency. So, it is concluded that the learning material is obtained using thinking map on the integrative learning model with good internal relevance and consistency.

**Keywords**—Embryology, thinking map, integrative learning

### 1 Introduction

Thinking map are the consistent visual pattern linked directly to eight specific through process and help students reach higher levels of critical and creative thinking. Because thinking map is the language of cognitive process pattern [1]. Each thinking map corresponds to a single thinking process such: *Circle map*—helps define words or things in context and presents points of view; *Bubble map*—describes emotional, sensory, and logical qualities; *Double bubble map*—compares and contrasts qualities; *Tree map*—shows the relationships between main ideas and supporting details; *Flow map*—shows events as a sequence; *Multi-flow map*—shows causes and effects and helps predict outcomes; *Brace map*—shows physical structures and part-whole relationships; *Bridge map*—helps to transfer or form analogies and metaphors [2].

Thinking maps make an excellent addition to any classroom, because the teachers teach the students to think critically about material of learning, and connections between the materials of learning [3]. Thinking maps could be utilized by the students to broaden critical thinking skills and enhance their understanding of the content graphic

organizers [3], like brain-based learning and multiple intelligences have been the focus of many workshops [4]. In other study showed that thinking map was also effective to improve science process [5]. Because to adopting the use of the strategy of thinking maps in teaching from the teachers as one of the effective means to the learner and making work ships aim to show the importance of using thinking maps strategy in teaching.

Previously, concept map was the tools used in learning that the effective dialogue between teacher and student [6, 7]. Concept map was an activity with numerous uses in the biology classroom, and it value in planning, teaching, revision, and assessment, and the attitudes of students and teachers towards its use. The concept map was assessed as an instructional strategy for use by high school students in learning biology concepts [8]. Concept map was discussed as a tool for the visualization of knowledge structures that can be exploited within biological education [9]. The concept map can be used to help students to improve their learning achievement and interests [10]. Concept map, a meta-learning tool, is appearing on the scene as a potential pathway for promoting the acquisition of problem-solving skills [11]. Teachers' use of concept mapping as an alternative assessment strategy in advanced level biology classes and its effects on students' cognitive skills on selected biology concepts [12].

The use of concept maps in biological learning is known from several research results. Concept map can be use on skeleton concept maps [13]. The content validity as well as application validity for the given concept map and argue for the practical relevance of the proposed validation frame-works [14]. The synergy that can be created when concept-mapping techniques are used in collaboration with the construction of power point presentations to increase the richness of the learning experience [15]. The use of five methods of representing cognitive structures - free word association, controlled word association, tree construction, concept map and flow map [11].

An integrative learning model has been designed [16, 17, 18]. In this learning model, teaching materials using thinking map is a part supporting system. There are five essential elements on learning model. The fifth component is syntax, the social system, the principles of reaction, supporting system and instructional and nurturing effect [19]. Integrative learning is a part of the modern instructional. Many integrative instructions identified to be part of the modern instructional design. Integrative instruction was as part of modern instructional design [20] that use in learning design [21] and to improved skill in biology learning [22]. The other articles are describing the integration of methods, strategies and learning materials [23, 24, 25].

At preliminary, the complex problems found on embryology learning in our institution, such as the using method of teaching is not equal with learning material, low mastery of learning, and embryology course is the main and prerequisite subject at Department of Biology Education, IAIN Batusangkar, West Sumatera Indonesia. The complex problems also show that students have different academic ability. The complete data is written in the research findings section. We think that providing a learning resource that includes a thinking map is one way to solve the problem. In this study, the research question is how the relevance and internal consistency of teaching materials using thinking map in the integrative learning model? The objective of the study was

to describe the relevance and internal confidence of teaching materials using thinking maps in integrative learning models.

## **2 Method**

This research is an educational design research consisting of phases: preliminary research, prototyping phase and assessment phase [26, 27]. In this study, learning material of embryology [28] used by 69 students who took the subject of embryology in the Department of Biology Education IAIN Batusangkar academic year 2017/2018. This study also involved 3 experts in the fields of embryology, learning technology and Indonesian language. The product assessment instrument validated by 3 experts and test result learning instruments measured its validity and reliability using  $\alpha$  Cronbach. The instruments used are validation sheets and learning outcomes test instruments. Validity validation test results are valid with a mean of 3.25. The results of the validity and reliability of the test results of learning outcomes in Cronbach are 81.52 and 75.54. Data on learning outcomes were analyzed by descriptive statistics [29].

The research procedure is at the preliminary, the researcher conducts an analysis of the characteristics of students. Student characteristics are based on cumulative achievement index, origin and school majors, anatomy courses and aptitude test results. At the prototyping stage, researchers designed prototype embryology teaching materials using thinking map. This prototype is assessed by experts [30]. Revisions are made on the basis of expert judgment. At the assessment stage, valid products are tested in the classroom on embryology learning. The trial was conducted for 8 meetings. The learning process uses the syntax of integrative learning models. At the end of the meeting a written test is conducted for students using instruments that have been developed previously. Product quality is determined from the aspect of relevance and internal consistency [31].

## **3 Result and Discussion**

The results of the study show that it has fulfilled the internal relevance and consistency aspects. This aspect of relevance and consistency is based on research findings on development characteristics, validity test and observation of learning process. The design and development process are based on findings on preliminary research. The results of the study at the preliminary stage showed that in the aspect of the cumulative achievement index, the highest average GPA of students was at 3.01-3.51 with a percentage of 41%. In the aspect of student learning achievement in the course of anatomy is in the B-, value that is equal to 31.5%.

Internal relevance and consistency in the development of teaching materials using thought maps can be seen from the research findings on aspects of product development characteristics. The prototype characteristics of teaching materials using mind maps are consistent, flexible, evolving, integrative and reflective [1]. These five characteristics are adapted to the development research process in education. The development matrix for teaching materials using thought maps is written in Table 1.

**Table 1.** The prototype matrix of teaching material development using the thinking map on the integrative learning model

No	Educational design research [26]		Characteristic [32]				
			<i>Consistent</i>	<i>Flexible</i>	<i>Growing</i>	<i>Integratif</i>	<i>Reflective</i>
1	Preliminary Research	Characteristics of students	•	•	•	•	•
2	Prototype Phase	Design prototype	•	•	•	•	•
		Expert review	•	•	•	•	•
		Revision	•	•	•	•	•
3	Assessment Phase	Summative evaluation	•	•	•	•	•

(•) indicates the component is in the matrix

The prototype design is carried out based on the prototype matrix for the development of teaching materials using thought maps on integrative learning models. The design results are listed in Table 2. In Table 2 it can be seen that there are 47 pieces of material visualized into eight types of thought maps. The results of this design were carried out by expert review with 3 experts. The results of the validity test are written in Table 3. The results of the validity test show that the prototype obtained a value with a valid average (Table 3), and the validator gives revised suggestions on the aspects of consistency in the use of terms in the thought map and the use of images in the product book. These results also show that there is internal relevance and consistency in the development of teaching materials using thought maps in integrative learning models.

**Table 2.** Teaching materials use thinking maps on integrative learning models

No	Thinking map	Content
1	Circle map (n=4)	Cleavage fields, oocyte cleavage and cleavage poles, blastula patterns, fate maps
2	Bubble map (n=8)	The scope of developmental biology, basic processes of development, structure of testes, proteins and molecules in the development of oocytes, spermatozoa capacitation, cleavage patterns, cleavage mechanisms, introduction of gastrulation,
3	Double bubble map (n=2)	Definition of development, the fate of amphioxus
4	Tree map (n=3)	Morphogenetic movements, mammalian blastocyst, the phase of human creation
5	Brace map	Oocyte development, comparison of spermatogenesis with oogenesis, the basic concept of gastrulation
6	Flow map (n=9)	Stages of spermatogenesis, reproductive cycle, spermatozoa changes from testes to ovum, fertilization, spermatozoa acrosome reaction, spermatozoa polarization, spermatozoa changes during fertilization, holoblastic cleavage, discoidal cleavage
7	Multi-flow map (n=9)	Development control, proliferation (mitosis), meiosis, chromosomal changes when meiosis, spermiogenesis, hormonal regulation of spermatogenesis, development of ovarian follicles, ovulation hormonal regulation, aves fate map
8	Bridge map (n=9)	Comparison of oocyte development with development of ovarian follicles, hormonal regulation of development of oocytes and ovarian follicles, regulation of oogenesis, regulation of the menstrual cycle, relationship of ovarian state to endometrium, relationship between capacitation, acrosome reaction and hyperactivation, division, amphibious gastrulation, mammalian blastocyst

The next stage is a prototype of teaching material using an assessment mechanism (assessment phase) using summative evaluation techniques. This stage also describes the practicality of using prototypes. Summative evaluation is done by applying the use of prototypes in the learning process. Application of prototype use in learning process using integrative learning model syntax. The practicality of applying this prototype is determined by student learning outcomes. The findings of the study on the results of the application of teaching materials using thought maps on integrative learning models are listed in Table 4. The test results showed that there were 36 students as participants obtained grades A, A-, B + and B. These results also indicated that the level of practicality of the prototype was at level is very practical and practical. This result also shows that there is relevance and consistency in the development of teaching materials using thought maps on integrative learning models.

**Table 3.** The results of the validity of teaching materials using a thought map on integrative learning models

No	Aspect	Result of validity (n expert = 3)		
		$\chi$	SD	Category
1	Consistent	2.72	0.71	Valid
2	Flexible	3.50	0.71	Very valid
3	Growth	3.00	1.41	Very valid
4	Integrative	3.50	0.71	Very valid
5	Reflective	2.82	0.71	Valid
Mean		3.26	0.85	Valid

Note:  $\chi$  = Mean, SD= Standard Deviation.  $\chi >3.20$  is very valid;  $2.40 < \chi \leq 3.20$  is valid;  $1.60 < \chi \leq 2.40$  is less valid;  $0.80 < \chi \leq 1.60$  is valid;  $\chi \leq 0.80$  is no valid.

**Table 4.** Students' learning outcomes after the implementation of teaching materials using thinking maps on integrative learning models

No	Scores and Quality	Number of students	Students achievement (%) (n students = 69)					Level of practicality
			Initial Assignment	Formative test	Sumative test	Practice	Mean	
1	A (85-100)	1	96.67	71.25	96	71.3	86.3	Very practice
2	A- (80-84)	5	93.88	71.14	86.16	78.58	83.58	
3	B+ (75-79)	8	88.74	67.41	75.62	76.6	77.45	Practice
4	B (70-74)	22	88.33	50.77	70.4	73.67	71.35	
5	B- (65-69)	10	87.33	48.37	58.6	76.49	67.32	Less practice
6	C+ (60-64)	7	83.33	42.85	56.57	68.84	62.97	
7	C (55-59)	5	73.33	29.74	53.4	72.38	57.46	No practice
8	D (45-65)	8	74.58	30.89	40.25	57.98	50.21	
9	E (<45)	2	68.33	27.65	22.5	62.6	43	

At the development process, internal relevance and consistency is determined by the existence of an initial identification process [33] of the products designed, and through the design, assessment and revision process. Formative evaluation is carried out on prototypes to reflect the level of product resistance to revisions [30] and documentation the

products that have been designed. These aspects were fulfilled in this study. The explanation also shows the existence of internal relevance and consistency in the development of teaching materials using thought maps on integrative learning models.

At internal relevance and consistency in educational development research is also determined by how much expectation is matched (expectation) with those of research findings [34]. The expected expectation of the research results is evidenced by a series of tests such as expert review and small or large group tests. The results of the research on the development of teaching materials using thought maps in this integrative learning model also show the existence of expert review and application tests (small large group tests). This finding also shows that internal relevance and consistency have been fulfilled in the development of teaching materials using thought maps in integrative learning models.

The results show that the developed subject meets five characteristics of the thinking map [1]. This result also shows that the developed teaching material can be visualized into the form of all types of thought maps. Because the research findings have helped to absorb the course material well. The results show that embryology learning materials can be visualized and support the lecturer's role in discovering and describing linear and nonlinear knowledge structures [32]. Embryological material has been visualized into eight forms of thought maps. The research findings also show that flow maps, plural flow maps and bridge maps are the most visualized type of embryological material. These results are suspected because embryological learning materials that are characterized by theories, processes, facts and concepts [35] can be met with flow maps, multiple plural maps and bridge maps [32]. Because the flow map visualizes the information settings in sequence. Plural flow maps visualize the analysis of physiological feedback systems and bridge maps visualizing the use of analogies and metaphors to understand concepts [32].

In terms of the use of learning methods, this study uses integrative learning model syntax supported by the theory of integrative learning approaches [36]. One of the most important aspects of an integrative model / approach is interdisciplinary, thought map and problem solving. The use of syntax of integrative learning model in learning process has direct impact [19] in the form of equalization of student learning outcomes on good quality. These findings also show that the fulfillment of the internal relevance and consistency aspects of the development of teaching materials uses the thinking map in the integrative learning model.

## **4 Conclusion**

This study concludes that teaching materials have been obtained using thought maps in integrative learning models with good internal relevance and consistency. The aspects of internal relevance and consistency are based on characteristic analysis, validity testing and student learning outcomes. More extensive tests (large group tests) are needed to increase product resistance to revisions.

The use of thought maps on content with the characteristics of theories, concepts, facts and processes should be more widely used in integrative learning processes. Because it will help students to achieve the learning materials. The use of thought maps should also involve students / students in the design process. So that the process of mapping and changing information to form (meta-cognitive) knowledge is more beneficial for students.

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