Using the ADDIE model to develop learning material for actuarial mathematics

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Abstract. The research is aimed to describe; (1) the development procedure of Actuarial Mathematics learning material with ADDIE model; (2) Validation of learning material using the ADDIE model for Actuarial Mathematics. The research method used is research and development using ADDIE Models. The instrument were used observation and questionare. The data were analyzed by descriptive qualitative and descriptive quantitative. The results showed that (1) the process of designing and development of the material teachings has followed the five steps in ADDIE model such as analyze, design, development, implementation, and evaluation. (2) The result of the content expert's validation was falling into agreement category, that of the instructional design expert's validation was agreement, that of the instructional media expert was agreement. There were some comment that given by expert about module. The average of student’s questionare were falling into good category.

1. Introduction
The development of actuary science is an important step in challenging the more difficult life day by day and in facing the unpredictable and very risky obstacles economically. Actuary occupies a very strategic position in financial industry for its role in predicting the opportunities in the future within its financial risks [1, 2]. For that reason, an actuary needs adequate knowledge in mathematics, statistics, economics and other supportive knowledge: a qualification that creates the number of actuaries in Indonesia are still low [3].

Based on the data listed in The Society of Actuaries of Indonesia (PAI) in 2015, there are about 400 new actuaries. The number is considered irrelevant with the high need of actuaries. Financial Services Authority of Indonesia (OJK) has proclaimed about 1.000 actuaries to met the need. Actuarial profession has very important role in analysing the risk and decision making in financial service industry. Nowadays, about 600 new actuaries are needed to fill the needs in about 140 insurance companies [3].

Actuarial mathematics was one of the subject that tested by PAI to got sertification as an actuarist [1]. To passed the exam, students must be influenced in life insurance models, contingent life annuities models, premium and premium reserves, multiple life models, multiple decrement models, claim models, and collective risk models [4,5]. Therefore, actuarial mathematics are seemed familiar to students and become important to learn.

The fact, many students not yet mastered topics in actuarial mathematics. This can be seen from many students who failed to take an actuarial Mathematics test conducted by PAI. This is caused by several factors. First, the lecture material in the Actuarial Mathematics course and the books used did not touch on the topics being tested. Second, textbooks that deal with Actuarial Mathematics are rare
and the context is difficult for students to understand, whereas in order to understand and apply theories to everyday problems, knowledge and understanding of concepts is needed. Facing this reality, it is important and urgent to do a development research that can produce an actuarial mathematics learning material, which can be used by both lecturers and students as well as the people who need it.

Research and Development as a process for developing and validating products that will be used in education and learning [6-10]. It is an effort to develop and produce a product in the form of material, media, tools and learning strategies, used to overcome classroom / laboratory learning, and not to test theory [11-14]. ADDIE model is one of the most common models used in the instructional design field as a guide to producing an effective design [15]. It has been used to develop curriculum in diverse fields such as library instruction [16] and online continuing education [17]. The steps of this model include analysis, design, development, implementation, and evaluation.

Based on the above description, it can be formulated two formulation of the problem as follows. (1) How the development procedure of module with ADDIE model; (2) How the Validation of module using the ADDIE model for Actuarial Mathematics?

2. Methods
The type of the research is research and development. The development model used is ADDIE. It is one of the systematic learning design models, chosen based on the consideration of this model is developed systematically and rests on the theoretical foundation of learning design. This model is structured programmed with sequences of systematic activities in efforts to solve learning problems related to learning resources that are in accordance with the needs and characteristics of students. This model consists of five step, namely: (1) analyze, (2) design, (3) development, (4) implementation, and (5) evaluation. Visually the ADDIE Model steps can be seen in Figure 1.

![ADDIE Model](image)

**Figure 1.** ADDIE Model [18]

The subjects are one subject matter experts, one learning design expert, and one learning media expert. The last trial subjects were eight students majoring in Mathematics in Universitas Negeri Medan who had taken actuarial mathematics. The data collected through the implementation of formative evaluations are grouped into four parts, namely: (1) the first stage of evaluation data in the form of subject matter content test results, (2) second stage evaluation data in the form of learning design expert test results, (3) the third evaluation data in the form of learning media expert test results data, and (4) fourth stage evaluation data in the form of data from small group trial results. The instrument were used observation and questionare. The questionnaire sheet was used to collect data from the review results.
from subject matter experts, learning design experts, learning media experts, and students. And finally, the data were analyzed by descriptive qualitative and descriptive quantitative.

2.1. Analysis
At the first step, activity done such as (1) analysing the competence must be mastered by the students; in real, in this textbook is realized by the determination of Standard Competencies, Basic Competencies, and Learning Purpose [19], (2) analysing the students characteristics relate to their knowledge, attitudes, and skills [16, 19], and (3) analysing the relevant materials to the competency achievements desired relate to what students master [16]. Analysis result of this step is self evaluated and continued evaluation with colleagues for the improvement of analysis results.

2.2. Design
The second step is focussed on three activities those are material choice relevant to the students characteristics and the competence to be achieved, learning strategy, assessment form and method and also evaluation [15,16]. In this step, textbook structure and content framework are designed. The result will be self evaluated and also with colleagues for the improvement of design results.

2.3. Development
There are several activities such as (1) Create factual sample for the instruction design; collecting relevant data resources to enrich the module, (2) Develop the materials of the course; making illustration, scheming, and creating graph needed, typing, editing, and also laying out the text book is performed, (3) Run through the conduction of the design; validating the draft of development product and revision after expert input will be performed [15].

2.4. Implementation
In this step, development result is applied in learning process to know its influence on the quality of learning covers the effectiveness, attractiveness, and efficiency. Implementation is applied on small group to get input from the students and lecturers as input for the revision of product draft.

2.5. Evaluation
The last step is evaluation covers formative and summative evaluations. Formative evaluation is performed to collect data on every step used to the improvement. Summative evaluation is done in the end of the program to know its influence on students learning outcome and the quality of learning extensively. This research only applies formative evaluation because this evaluation relates to the steps of development research to uplift development product resulted. Evaluation in ADDIE model has been done step by step.

After the module of actuarial mathematics fully improved, validation on the product resulted is performed. The elaboration of test result of development product by experts such as experts of learning module, the experts of learning design, the experts of learning tools till test on small group with students as its test subject. In analyzing the validity, Content Validity Ratio (CVR) by Lawshe [20] is used; the equation is as follow (1).

\[ CVR = \frac{n_e - \left(\frac{N}{2}\right)}{\frac{N}{2}} \] (1)

Where CVR is validity ratio, \( n_e \) is the number of panel members indicating an item essensial and \( N \) is the number of panel members. The validity criteria of learning material are shown in the table 1. [21].

| Interval | Category       |
|----------|----------------|
| -1       | Perfect disagreement |
| +1       | Perfect agreement |

Table 1. Validity Criteria
Small group Students’ assessment are observed by using the questionnaire sheet. It is shown in Table 2. [16]

| Interval  | Category |
|----------|----------|
| 3.60-4.00 | Very good |
| 2.60-3.59 | Good      |
| 1.60-2.50 | adequate  |
| 0.00-1.59 | less      |

### 3. Result and Discussion

Development design of teaching materials of actuarial mathematics has followed the five step of ADDIE model. Analysis step is the beginning step or the first step of ADDIE model. In this step, three important things are done which are (1) analysing the competence that must be mastered by the students, (2) analysing students characteristics relate to their knowledge, attitudes, and skills had by the students, and (3) analysing the relevant material for the competency achievements expected to be had by the students. In the last of this step, evaluation is done to find out the weaknesses and to perform revision as needed.

Second step of ADDIE model is design. In this step three activities are done which are (1) material choice relevant to the student characteristics and competence demands expected, (2) learning strategies, and (3) assessment and evaluation forms and methods. Structure and design of text book are set in this step. Then, learning strategy implemented for every chapter is set in order to make the module easy to be learnt and understood by the readers. How to measure the achievement of learning purpose after the reader learnt the material in every chapter is also determined. As the first step, in the end of this step evaluation is performed.

Development is the third steps of ADDIE model. The activity in developing textbook prototype. Searching and collection relevant data sources to enrich the materials, illustration making, scheme, and graph needed, typing, editing, and also lying out of textbook are parts of this step. Validation of textbook prototype is performed in this step.

Involved validators are the experts of content, learning media, and learning media. Analysis and revision on textbook prototype of development research model are performed after the first validator gives his assessment result, and so on until the analysis and revision on the assessment result of third validator.

The forth is implementation. The prototype of development product is tested in the real class and used by the students. Under the time limit, the textbook prototype of development research model is implemented in small group. After the implementation, the small group which consists of 8 students of Semester V, Mathematics Department are asked for assessing the prototype of development product.

The fifth or the last step of ADDIE model is evaluation. There are two kinds of evaluation those are formative and summative evaluations. This research only implements formative evaluations aims to validate the development product and revises in accordance with the input or suggestion given. In accordance with the development of ADDIE mode, formative evaluation has been performed step by step in every step of ADDIE model.

#### 3.1. Product

The product resulted from this research and development is actuarial mathematics learning material based PAI exam syllabus. The learning materials developed contain life insurance models, contingent life annuities models, benefit reserves, multiple life models, multiple decrement models, claim models, and collective risk models [4,5]. The learning materials are in the form of printed materials of modules. The developed learning material contains cover, introduction, table of contents, concept maps, achieved competence, indicators, material summary, competency test, glossary, and bibliography.
3.2. Validity
The results of learning materials validation are shown in tables below:

| No | Aspect of assessment                                                                 | CVR  | Category |
|----|--------------------------------------------------------------------------------------|------|----------|
| 1. | The accuracy of the chapter title with the contents of the material in each chapter. | 1,00 | Agreement |
| 2. | Conformity between concepts and content.                                              | 1,00 | Agreement |
| 3. | Conformity between competency standards and learning objectives.                      | 1,00 | Agreement |
| 4. | Operational learning objectives.                                                      | 0,60 | Agreement |
| 5. | Conformity between learning objectives and material exposure.                         | 0,60 | Agreement |
| 6. | Clarity of material description.                                                      | 0,60 | Agreement |
| 7. | Clarity of examples given.                                                            | 0,60 | Agreement |
| 8. | Conformity between tables, charts, drawings / illustrations and material.             | 0,60 | Agreement |
| 9. | The accuracy of the selection of summary content.                                    | 0,60 | Agreement |
| 10.| Conformity between the final chapter test and learning objectives.                   | 0,60 | Agreement |
| 11.| The accuracy of the bibliography that can be used as a reference search reading resources that are relevant to the material. | 0,60 | Agreement |

Mean 0,71 Agreement

Table 3 shows that there are 11 assessment from expert on content. The result of analysis based on the mean score of all the aspects is 0,71 with agreement category. It means that module of development research model is on the range of good qualification so that the module revised as needed. Quantitatively, through closed questionnaire on module of development research model is revised as needed. Qualitatively through opened questionnaire, expert on content gives an input. Clarity of material description need to be looked closely more in order to make it clearly and easy to understand students. Moreover, Afrahamiryano [22] stated that a learning material can be said as valid, if it is suitable with the required learning materials, clear and accurate materials, and able to motivate students.

| No | Aspect of assessment                                                                 | CVR  | Category |
|----|--------------------------------------------------------------------------------------|------|----------|
| 1. | Cover quality                                                                       | 0,60 | Agreement |
| 2. | Pull cover design                                                                    | 0,60 | Agreement |
| 3. | The accuracy of typing layout                                                        | 0,60 | Agreement |
| 4. | Consistent use of spaces, titles, subtitles, and typing material                    | 0,60 | Agreement |
| 5. | Writing / typing clarity                                                             | 0,60 | Agreement |
| 6. | Completeness of the components in each chapter of teaching material.                | 0,60 | Agreement |
| 7. | The accuracy of the way the material is presented                                   | 0,60 | Agreement |
| 8. | The accuracy of placement of charts, tables, or images illustration                 | 0,60 | Agreement |
| 9. | Clarity of order of material presentation                                            | 1,00 | Agreement |
|    | Mean                                                                                 | 0,64 | Agreement |

Table 4 shows that there are 9 assessment from expert on learning design. The result of analysis based on the mean score of all the aspects is 0,64 with agreement category. It means that the module of
development research model is at good qualification so that a few revision needed. Quantitatively through closed questionnaire, the module needs to be revised as needed. Qualitatively, through opened questionnaire, learning design expert give suggestions to revision is done by revising some basic competencies use verbs which cannot be measured to be the measured one.

**Table 5. Assessment from learning media expert**

| No | Aspect of assessment                                      | CVR | Category |
|----|----------------------------------------------------------|-----|----------|
| 1. | The accuracy of the illustrations used in the cover      | 0,60| Agreement|
| 2. | Conformity between material and media used               | 0,60| Agreement|
| 3. | Quality of charts, tables, or images used                | 1,00| Agreement|
| 4. | Accuracy in size of charts, tables, or images            | 1,00| Agreement|
| 5. | The accuracy of the placement of charts, tables, or images| 1,00| Agreement|
| 6. | Text quality                                             | 0,60| Agreement|
| 7. | Quality of binding                                       | 0,60| Agreement|
|    | Mean                                                     | 0,77| Agreement|

Table 5. shows that there are 7 assessment from expert on learning media. The result of analysis based on the mean score of all the aspects is 0,77 with agreement category. It means that the module is so qualified that revision is not necessary. Quantitatively through closed questionnaire the module is no need to be revised. Qualitatively through opened questionnaire, learning media expert gives a suggestion which is to manage the line in the summary, so that not coincides with the summary.

**Table 6. The results of the trial in a small group of students**

| No | Criteria                                             | I   | II  | III | IV  | V   | VI  | VII | VIII |
|----|------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|------|
| 1. | Physical appearance of module                        | 3   | 3   | 4   | 3   | 4   | 3   | 3   | 4    |
| 2. | The size and type of letters used                    | 4   | 4   | 4   | 4   | 4   | 4   | 4   | 4    |
| 3. | Clarity of learning objectives                       | 4   | 4   | 4   | 3   | 4   | 4   | 3   | 4    |
| 4. | Clarity of material exposure in each chapter         | 4   | 3   | 4   | 3   | 3   | 4   | 3   | 4    |
| 5. | Compatibility between pictures and material          | 4   | 3   | 3   | 3   | 3   | 4   | 4   | 3    |
| 6. | The examples provided help you understand the material| 4   | 4   | 4   | 3   | 3   | 4   | 3   | 4    |
| 7. | Level of clarity of summary                          | 3   | 3   | 3   | 4   | 3   | 3   | 3   | 4    |
| 8. | Test at the end of the chapter                       | 3   | 3   | 3   | 3   | 3   | 4   | 4   | 4    |
| 9. | The order of presentation of the material in each chapter| 3   | 3   | 3   | 3   | 3   | 3   | 3   | 3    |

| Mean                  | 3,56 | 3,44 | 3,56 | 3,44 | 3,44 | 3,44 | 3,67 | 3,78 |

Based on the results of the trial in a small group of students, obtained average is 3, 54 (good category). It means that the module is qualified, so that can be revised as needed. Quantitatively, through closed questionnaire, graphical media of contemporary puppet is revised as needed. Qualitatively through opened questionnaire, students give comments in general that the module is qualified. A suggestion given by the student mentions that the cover especially for the colour of title need to be revised to make it interesting.
4. Conclusion
The result of the research shows that:
1. The material learning of actuarial mathematics has been developed based on ADDIE model which covers 5 steps. Those are analysis, design, development, implementation, and evaluation. Development design of module of actuarial mathematics has been relevant to the 5 steps of ADDIE model.
2. Validation results of module of actuarial mathematics show that based on the calculation (1) of the mean given by content expert is 0.71 (agreement) so that needs a few revision as necessary, (2) of the mean given by learning design expert is 0.64 (agreement) which means that need a few revision, (3) of the mean given by learning media expert is 0.77 (agreement) which means that the module does not need revision. Quantitatively, there are some suggestions given by experts. The average score of validation result given by the students on the material learning product is 3.54 (good) which means need a few revision. In general, students state that the module is qualified and easy to be understood. One suggestion given by student mentions that the cover must be revised to make it interesting.

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