

EVOLUTIONARY APPROACH: FROM SOFTWARE DEVELOPMENT MODEL TO LEARNING METHOD

Viet Hai Ha

Hue University's College of Education, Vietnam

haviethai@gmail.com

ABSTRACT

How to make long and difficult lessons become easy, interesting and effective for learners is always a difficult question. In software engineering, there is the same question when developing big and complex information systems and the evolutionary model is a good solution in these cases. This paper aims at presenting this model and the ability to apply its main ideas into teaching – learning method.

Keywords: *evolutionary learning, evolutionary model, learning theory, teaching theory*

I. WATERFALL MODEL AND EVOLUTIONARY MODEL IN INFORMATION SYSTEM DEVELOPMENT

Within the appearance and development of electronic computers, the software engineering started in the 50's decade. Requirements to create an unceasingly increased number of complex information systems led to the development of system analysis and design method as an important element of software engineering. Generally, most methods agree that the development of an information system should be through the phases: problem definition, system analysis, system design, coding, testing, implementation, and maintenance. The general purpose and the plan of system development are defined in the first step. Logical requirements of system are analyzed and specified in the system analysis phase. The system design phase designs the physical future systems based on the logical requirements specified in the previous phase. Physical system is really created in the coding phase, and after being tested, it is implemented in the real environment. The final phase – maintenance phase – consists the duties of repairing bugs and making minor changes or minor improvements according to user's requirements.

Although the phases in the process of

developing an information system is quite stable but the way of organizing, coordinating between these phases can be different. This way has important impacts to the methodology, the method and the pace of work, and as consequence have influences to the quality and delivery schedule of the system. Some methods of organization have been created and widely used such as the waterfall model, evolutionary model, iterative model and spiral model. This paper restricts to the first two models.

1. Waterfall model

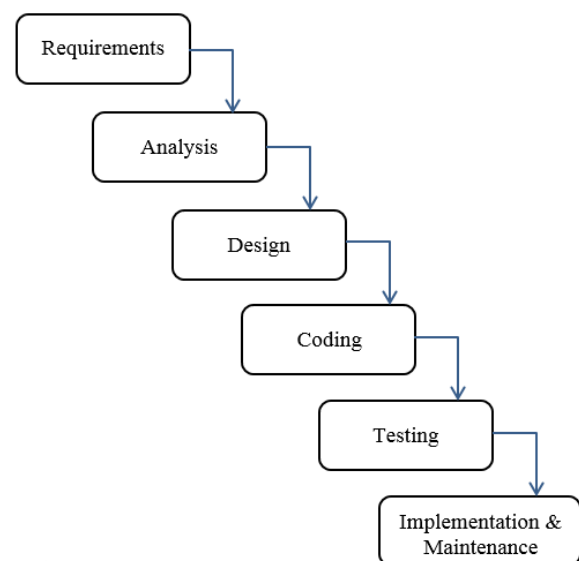


Figure 1. The Waterfall model

The waterfall model (Gilb, 1985) appeared earliest, based on the idea of a maximally avoid the cases where developers have to go back to previous phases for repairing the errors that found in the current phase. The basic principle of the waterfall model is implemented as sequential steps going down a waterfall with maximum effort so that every step should be taken only once. In case there is an error that is caused by one of the previous steps is found, the process step-by-step returns back until meeting the source of the error. After fixing the error, the process re-initializes at the step causing it. Figure 1 presents the principles of the waterfall model.

The waterfall model has two important characteristics:

- All plans are oriented on a unique delivery, after finishing the whole system, usually after a half of year to few years.
- All the analysis and design phases must be completed in details before the coding phase.

The waterfall model is suitable for system development when:

- Requirements are well known in advance;
- There are no high risk, unresolved cost implications;
- The nature of the requirements will not change significantly;
- The requirements match the key stakeholders' expectations;
- There is enough time to proceed sequentially.

Although the waterfall model has outlined a clear roadmap for the development of an information system, but the steps carried out sequentially encountered some difficulties in practice for complex systems because these system always contains too many of unknowns, too much dynamic change and too complex interrelations. All of them require a large amount of time and resources to correctly specify all system's components in once. Furthermore, for developing large systems that contain many components and

many targets, the waterfall model leads to a long delivery time while in most cases clients accept the delivery of products at many times, in the form of intermediate products or their components. This leads to appearances of some other models such as the evolutionary model, spiral model, and iterative model that mostly have the same steps as the waterfall model but are more adaptive and more flexible.

2. Evolutionary model

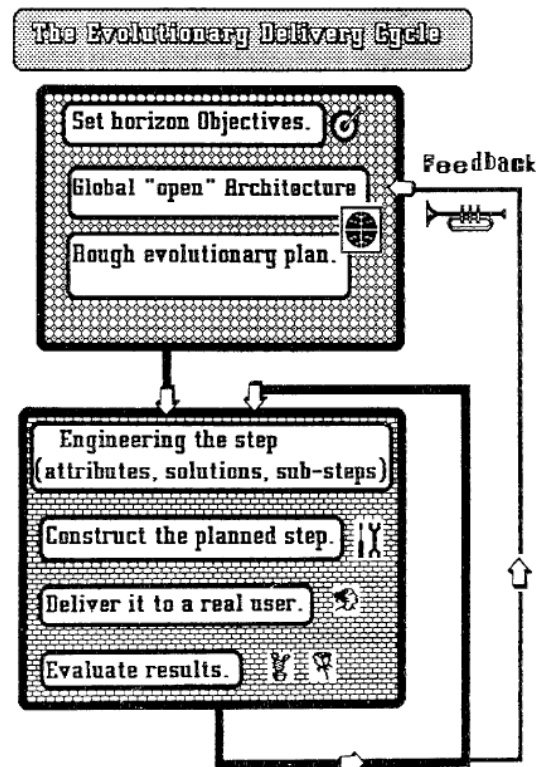


Figure 2. The Evolutionary model

Evolutionary model (Gilb, 1985) was first officially mentioned by Tom Gilb in 1958. Nowadays, its basic characteristics are integrated in the spiral model (Boehm, 2000). However, in the later form, its most important idea – the evolutionary characteristic – does not clearly remains. This paper backs to the original principles of the evolutionary model with the fundamental difference while compared with the waterfall model is that one system is developed and delivered in many iterations rather than just once. The principles of evolutionary model are:

- Develop and deliver an initial system to the real end-user;

- Measure the added-value to the user in all critical dimensions;
- Adjust both design and objectives based on observed realities;
- Revolute the system according the adjusted design.

Figure 2 presents the principles of the evolutionary model. For more details, refer (Gilb, 1985).

Teaching – learning process from the view point of an information system development

Teaching – learning process can be considered as a process of developing an information system with equivalent steps described in Table 1.

No.	Information system development process	Teaching – learning process
	Objective is developing for end-users a new information system	Objective is developing new knowledge, skills, attitudes... for learners
1	Define system’s objectives	Define learning objectives
2	Analysis system’s requirements	Analysis learning requirements
3	System design	Learning process design
4	Coding, testing	Creating, testing lesson
5	Implementing	Teaching – learning
6	Maintenance	Testing (learning results), adjusting, improving the teaching – learning process design

Table 1. Information system development process vs teaching - learning process

In the Table 1, there are following notes:

- The right column refers to a teaching – learning process, with the objective is developing for learners a set of knowledge, skills, and attitudes... instead of referring to a lesson development process with the objective is creating the lesson.
- Since a lesson can be used many times, the phases from 2 to 4 in the right column may be different between the first time and the others. In the first time, this process composes the task of lesson developing, therefore all the steps are completely done. In the other times, some steps may be in form of adjusting based on the feedbacks of the previous times and current conditions.
- There is a difference between an information system development process and a teaching – learning process in the clarity of the objectives and the relations between

their components. They are quite unclear and can be open at the beginning of a software project while in most cases of the teaching – learning process, they are very clears.

From this view point, most current teaching – learning methods are sequential, it means they use the waterfall model, except some ones such as the programmed learning method (Skinner, 1958) (Roe, 1962) and the project based learning method (Knoll, 1997). In the programmed learning method, lessons are divided into small frames within own assessments and the learning process may be different between learners. In case of project based learning method, all project development models can be applied.

Similar with a process of development an information system, the teaching – learning process in cases of long, complex lessons meet many difficulties if it is sequentially executed caused by the following reasons:

- Sequentially executing requires each phase is performed only once and so each phase will contains many

elements, many complex interrelations which easily exceed the learning ability of learners. Thus lessons become difficult for them.

- The plan that is oriented towards a single result at the end of learning process takes learners a long time since the beginning of lesson (normally they are in ready and interested status) to the moment where they can see the result. As a consequence, they will be tired and dejected.
- The test and evaluation at the end of learning process is too late for finding situations where learners could not follow the learning process. Sooner finding these situations, lesser the depending to overcome them.

Comparing with the basic objective of teaching – learning methods as mentioned in the abstract session, it is not good to applying the sequential model for the long and complex lessons. In these cases, the evolutionary learning model based on the evolutionary system development in software technology can give better results. The principles of this method is initially established in the following sections.

II. EVOLUTIONARY LEARNING METHOD

1. Definition

Evolutionary learning is a learning method in that learners reach to general learning objectives via a series of steps, each step aim to reach some component objectives, following steps inherit and evolve previous ones.

2. Characteristics

Below are six main characteristics of the evolutionary learning method, specified by considering the characteristics of the evolutionary model in information system development (Gilb, 1985) from the view point of a teaching – learning method.

1. Multi-objectives driven: it is established not only in the general objectives but also in the sub

objectives of each step. These sub objectives can be the components of the general objectives or the immediate objectives or can be integrated with the objectives established by the requirements of various aspects of teaching – learning process.

2. Early and frequently iteration: the general objectives are divided into many sub objectives, each iteration (step) aims at reaching one or some sub objectives. By this way, the result of teaching – learning process can be viewed not only at the end of process but also at the end of each step. One special request of the evolutionary method is the content and/or the objectives of one iteration have to inherit, evolve from the previous ones, it means that each iteration is an “evolution” of the previous ones. If this request is not satisfied, the learning process will not compliant with the evolutionary model.
3. Complete analysis, design, build and test in each step: it is the key characteristic of evolutionary model in information system development. However, there is a difference for the “horizontal objectives” in case of evolutionary learning method since in most teaching – learning cases, general objectives are quite clear and can be correctly specified at the beginning. The evolutionary characteristic of learning process exists in two aspects: 1) the evolutionary relationships between steps, and 2) the adjustment after steps. It is possible there is an evolution between different times while teaching – learning a lesson.
4. Learner orientation: this feature is mainly expressed in two factors: 1) the main objective of the method – making the learning process become easier and more interesting for learners, and 2) the requirements that each step of learning process must have obviously and meaningful objectives

for learners.

5. Open-ended architecture: this is mandatory in the case of information systems development but not mandatory in case of evolutionary learning process. This is derived from the difference in the clarity of objectives as well as the relationship between the components.
6. Result orientation, not process orientation: this is due to the basic idea of the method that requires an organization of the learning process in a series of evolutionary steps towards the general objectives. So each step is determined first by one or more sub objectives and then the design of learning process is oriented by a clear result-orientation direction that goes out the form constrains.

3. Advantages and drawbacks

Based on the concepts and the characteristics mentioned above, advantages and drawbacks of the evolutionary learning method are described below, as author's initial opinions.

1. It provides a good direction to organize long and complex lessons: this due to the basic ideas of the methods. The lessons are organized in many steps that ensure the evolutionary relations and toward their general objectives. The inheritance and evolution between steps also strongly increase the logical characteristic in the structure of lessons and it is a good suggestion while designing the learning processes.
2. It makes the learning process in case of long and complex lessons become easy, fast, and thorough: breaking a lesson into many steps having clear objectives make it become easier to learn. The clear and meaningful characteristics of the global objectives and component objectives stimulate learners' enthusiasm. The evolutionary interrelations increase the logical characteristic of lessons and then stimulate learners' enthusiasm when they begin a new learning step. Since each step is not too long, the stimulus is maintained throughout the learning process and speed up the learning.
3. It is accordance with the learner-centered approach (Thai, 2008) in modern teaching – learning theories: this advantage derived from the fourth characteristic mentioned above. From the initial global objectives, the learning process is designed in a view point of priority to ease the learning process, belong to a roadmap that familiar with the logical awareness and stimulate the interest of learners, not just to rely on the knowledge.
4. It is appropriate with the learning processes that have open objectives: in these cases, the model is presented in Figure 2 that can be strictly applied to organize the learning processes. It means that beginning by establishing the horizon objectives and a rough plan, then make the details with a series of evolutionary steps. The evaluations and feedbacks at the end of each step are used to establish the next step and to ad justify the initial horizon objectives.
5. It is appropriate with the approach of objective-oriented learning and it make easier to modify the learning process: lessons are designed towards the learning objectives and not much depend on the form. Thus learning process can be flexibility modified or personalized in each specific situation in order to reach the global and component objectives.
6. It is easy to coordinate with other learning methods: it can be easily combined with the programmed learning methods, in which each step is used as a frame, the result of the test at the end of each step is used to control the learning process. From the view point of the problem-solved learning, the component objectives of each step and the evolutionary relations between steps of the revolutionary model are good

suggestions to set up problem at the beginning of each learning step. With the evolutionary and open-ended characteristics, the evolutionary learning method is also suitable for organizing the project-based and problem-based (Woei, 2008) methods.

7. The biggest drawback of the evolutionary learning method dues to its applied range. It is only appropriate for long and complex lessons that can be spliced into many components within the objectives and contents having evolutionary interrelationships. Furthermore, the work of designing a lesson satisfies the requirements of the methods usually takes a lot of effort and wisdom.

III. CONCLUSION

The rapid development of the modern society poses many demands for teaching – learning theory in which the way to organize learning processes so that learners can easily, stability and fully get knowledge is one of the basic ones. This paper aims at introducing the evolutionary learning – a new method to reach these demands. This method provides the suggestions to make the learning processes of long and complex lessons become easier, quicker and more exciting. The ideas, characteristics, advantages and disadvantages of the method have been presented as author's initial reasoning. Therefore, it is necessary to have more

researches, more discussions and more experiments to develop this method.

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