Evaluating the Innovation of Emerging Technology Curriculum

Lung-Hsing Kuo

***Abstract*—**Learning technological literacy is a way to prepare for innovation. How to evaluate the innovation characteristics of a emerging technology curriculum becomes a concern for promoting innovation. The purpose of this study was to create an evaluating model to measure innovation of the educational reform in a High School Emerging Technology Curriculum in Taiwan. A CIPP model was served as a foundation for both formative and summative evaluations. The core concept is based upon innovation is the target of curriculum reform. In Taiwan, science educators are seeking ways of copying emerging technology. This study is a part of response to that call. This study suggested that innovation should be supported during the process but not only the end. According to the formative evaluation results from contest, input, process, and product stages, stack holders such as administrator, teacher, student, and parent could provide better efforts to maintain innovation. For better supporting science education reform, there is a need to find a systematic evaluation for innovation of curriculum reform. The identified structure was presented and discussed in response to the innovation evaluation.

***Keywords*—**Innovation Evaluation, Emerging Technology Curriculum, CIPP Model.

I. Introduction

PEOPLE use technology to extend their ability to gain control and innovation. Learning is the core step of reaching innovation. Formal education reform would be the main head of innovation train. In Taiwan, education had been playing the role of leading national innovation for last decade.[1-3]

Evaluation is a mean for understanding how things going. Based on the evaluation goal, criteria should be identified before evaluation could be conducted. There is a need to create a system to pin point effects of integrating emerging technology into formal technology education, so can reveal the integral information and characteristics of curriculum innovation[2, 4-6].

Technology education is a subject area of common education and provides learner the opportunity of understanding technology. New technology grows everyday and the information and knowledge of technology expands, too. Systems of technology in some areas are even exploded, such as energy & power technology and information & communication technology. In science education, how to integrating emerging technology into formal education becomes a concern. Education reform acts in Taiwan pointed out this trend and raised a “High Scope Curriculum Development” project to foster emerging technology education reform.

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II. Problem Formulation

Evaluation is an integral part of instructional design. Formative evaluation, specifically, is a phase identified in many instructional design models and should be recognized as an important step for program improvement and acceptance. Although evaluation has many models and approaches, very few deal specifically with formative evaluation.

Further, no one set of guidelines has been found that provides a comprehensive set of procedures for planning and implementing an innovational evaluation of integrating new content into formal curriculum.

A. Technology Education

Technology is an integral part of our social structure. This structure can be defined in part by its use of technology which transforms the environment, ideologies, and its sociological elements. It is this interaction, that is, the dependence of humans on technical means for survival, that warrants the study of technology by all people[7].

Survival of the human species has continuously relied on means to adapt to the natural environment. Humans, constrained by their biological inheritance, have been forced to utilize support mechanisms for their sheer survival[8]. By creating technical means for this survival, hun1ans were able to adapt both physically and socially. The acquisition of these technical means has been cumulative over the years with each new element adding to the existing inventory of knowledge. Archaeological evidence reveals the use of technical means in the past and it is obvious that our reliance on our technology has not diminished today. As a result, the nature of humans is expressed in cultural contrivances, both tangible (e.g., tools, machines) and intangible (e.g., ways of thinking).

One of the major contributors to the exclusivity of our culture over the last quarter century is the scope and pace of technological change. Since we do not inherit culture through genetic transformation, we must rely on our exposure to information.

In this way, culture is learned. Understanding and coping with technology was relatively easy decades ago. However, today, making sense of culture on a global basis is a difficult task due to the avalanche of inventions and innovations.

A society is a group of people working as a cohesive unit bound together by its culture. Within society is the human endeavor called technology. Therefore, it is the human who conceives what should be developed, and it is the hun1an who should control its destiny. One significant challenge is to ensure that technical means are used appropriately for the welfare of all people without dan1aging the natural environment. It is imperative, therefore, that information be available for all people information that is accurate and usable. The primary vehicle for this dissemination is the educational enterprise. Just as society advances technologically, so must its educational system, thus enabling individuals to make a commitment to generating a society and environment that are human and controlled for the betterment of humankind.

The massive growth of technology and technology transfer has introduced us to the realities of an interdependent world. Global culture has moved within the past decade from self-sufficient economies to an integrated system of global production.

The use of technology is a global phenomenon with no country immune to the need for extending the potential of the human being. Willie not all countries have developed equally in a technological sense, it is clear that today new technologies will develop ·where human resources and commitment exist. No longer is the greatest asset capital or natural resources, but rather the ability to use information. Information is one of the most useful resources in developing and managing technological systems. However, there is still considerable degree of flexibility, in duding the widespread use of methods derived from phenomenology and critical science, due to the nature of what is studied human behavior. The primary method of knowing for technologists is a problem-centered approach, governed by human needs and wants, called the Technological Method. Technologists' activity is based on the pragmatic desire or need to solve human problems[9].

B. Evaluation

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Dick et al. [10, 11] distinguish between formatively evaluating one's own instructional materials and formatively evaluating externally selected materials. Many evaluation articles, strategies, and tools are designed towards the end-user (instructor, teacher, etc.) to help to determine the effectiveness or appropriateness of a piece of instruction or instructional material once selected. "Although most evaluation theorists have said that their models are intended to influence and assist audiences, for the most part the nature and the role of these audiences has been given little or no special emphasis".[11, 12] The author's interest focused on the formative evaluation of instruction by the designer or developer within the context of the instructional design process. This study was helping designers and developers incorporate the step of formative evaluation of integrating immerging technology into formal into their design process for the purpose of improvement, not leaving it to the end-user to determine appropriate fit.

TenBrink [13] identifies three things that a model of the process of evaluation should do:

1. Clearly specify each step in the process of evaluation

2. Be applicable to all types of evaluation problems

3. Be easy to understand and easy to use

Tessmer [14] notes that all formative evaluations will follow these general steps:

1. Plan the evaluation

2. Introduce the evaluation to participants

3. Conduct the evaluation

4. Gather and organize data

5. Make data-based revisions

6. Evaluate revised version (if possible)

Most formative evaluations follow the same procedures. However, what was found when reviewing the literature to find the most comprehensive formative evaluation on which to base a tool was that no one model contained all steps that the author felt was necessary. Some steps might be considered optionally.

III. Problem Solution

In this session, a proposed CIPP based innovation evaluation structure would be presented according to the innovation theory.

A. Innovation Theory

The common foundations through which theorists study the adoption and development of new ideas is commonly known as Innovation Theory or Diffusion Theory. In its essential form, Diffusion is defined as the process by which an innovation is adopted and gains acceptance by individuals or members of a community.

Diffusion Theory represents a complex number of sub-theories that collectively study the processes of adoption. Perhaps the first famous account of Diffusion research was done in 1903 by French sociologist Gabriel Tarde [15]. Tarde plotted the original S-shaped innovation curve as he believed that most innovations have an S-shaped rate of adoption. Through the slope of the S-curve, Tarde could identify those innovations with a relatively fast rate of adoption (steep slope) versus those with a slower rate (gradual slope). Since Tarde, the S-slope has become important for those studying the adoption of ideas, especially those found in business.

Rogers [16] defines the adoption process as "the mental process through which an individual passes from first hearing about an innovation to final adoption". The five steps in this process are regarded as

- knowledge (awareness),
- persuasion (interest),
- decision (evaluation),
- implementation (trial) and;
- confirmation (adoption).

Throughout the adoption process, the individual seeks knowledge of and skills which will ultimately affect the adoption process. For a potential adopter, the process will proceed through the various steps and lead to adoption, or alternately, lead to rejection of the innovation. [16]

Rogers also offers a very scientific approach to understanding the rate of adoption. Rogers [16] has developed five variables which affect the adoption rate of any particular innovation. These include

1. perceived attributes of innovations (discussed earlier),
2. type of innovation-decision,
3. communication channels,
4. nature of the social system, and;
5. extent of change agents' promotion efforts.

Rogers' model could help a researcher to consider the basic forces which affect both adoption rates, and the factors which may lead to the rejection of an innovation. However, in its own simplicity, which may be ironically its strength, it is limited in explaining complex human systems.

As an observation of Rogers' work, it is believed that the models created here could help to describe both top-down (macro-level) and bottom-up (micro-level) change models. As Rogers' work[16] seem to be really a comprehensive meta-theory, the focus could possibly allow for the study of both systemic and individual change.

Technological Determinists May Ask Questions Such As:

- What was the effect of the automobile on society?
- What did the typewriter do to the balance of gender power in the office?
- How has television affected school violence?

The assumption here is that "Technological innovation can directly cause social change." More so, technological innovation (itself) can be attributed as a determining factor for adoption.

Technological Instrumentalists May Ask Questions Such As:

- How do we encourage people to be more conscious about the environmental effects of purchasing sport utility vehicles?
- How do we convince the major television networks to produce less violent programming?

The assumption here is that "It is understood that the adoption of an innovation depends strongly on the context (the people, organization etc) in which it might be used". This is an important issue because there is often a common perception that with technology, positive change will commence, and that it is in fact technology itself driving this change. This is often a prevailing thought in educational systems especially. Postman criticizes this mindset and writes, "school boards are now preparing to spend, in aggregate, billions of dollars to wire schools in order to accommodate computer technology; and for reasons that are by no means clear" [17]. Richard Stoll [18] also stabs at the assumptions some educators and administrators make toward the implementation of technology into schools. In refuting the famous McLuhian cliché "information is power", Stoll writes, "Information isn't power. Who's got the most information in your neighbourhood? Librarians, and they're famous for having no power at all. Who has the most power in your community? Politicians, of course. And they're notorious for being ill-informed" [18].

Opposed to the determinist view of technology, lie the instrumentalists. Instrumentalists view technology as a tool, and humans as masters of the tool. In some cases, Instrumentalists cite the knife as an example of their philosophy. For instance, a knife is a tool that can be used for good or evil depending on an individual's desires [19]. Also, "while determinists see technology as the most powerful force for change, instrumentalists see social conditions and human aspiration as the primary causes of change" [20]. While the determinist/instrumentalist debate can go on forever with likely no winner, it's important to consider one's stance on the affect of technology itself on the change process.

Practically, the distinction between determinists and instrumentalists does not appear so "black and white". This is where theories of social constructivism related to development and adoption of technology may be beneficial for better understanding. While social constructivist theories vary, some key characteristics and commonalities are represented in Brey [21]:

Social constructivism includes a conception of technological development as a contingent process, involving heterogeneous factors. Accordingly, technological change cannot be analyzed as following a fixed, unidirectional path, and cannot be explained by reference to economic laws or some inner technological "logic." Rather, technological change is best explained by reference to a number of technological controversies, disagreements, and difficulties, that involve different actors (individuals or groups that are capable of acting) or relevant social groups, which are groups of actors that share a common conceptual framework and common interests. These actors or groups engage in strategies to win from the opposition and to shape technology according to their own plan.

For traditional understandings of technological invention, it may be sufficient to state that "Edison invented the light bulb" or "Ford invented the Model T". The notion here is that inventions occur when brilliant individuals create new technologies, ready-formed and market ready. However, in social constructivist theories, there is a tendency to shift away from the idea of invention toward the idea of technological development which occurs over time and is subject to many forces. Thus, social constructivism moves away from "heroes" or a few key historical names toward a complex and seamless web of interests that may include economic, political and social change factors.

Table 1 Components of CIPP Evaluation

Formative and Summative Evaluations
Context evaluation
Input evaluation
Process evaluation
Product evaluation

B. CIPP

In Table 1, the CIPP Model (Context, Input, Process, and Product) can be used for both formative and summative evaluation[8]. Perhaps the most significant characteristic of CIPP is that it makes provision for holistic evaluation. Its elements are systems oriented, structured to accommodate universal evaluation needs. They also notes the rarity of an evaluation model that offers process evaluation, as this one does[22, 23].

- *Context evaluation,* to serve *planning decisions* –"is intended to describe the status or context or setting so as to identify theunmet needs, potential opportunities, problems, or program objectives that will be evaluated" .

- *Input evaluation,* to serve *structuring decisions* –"the evaluator provides information to help the decision maker select procedures and resources for designing or choosing appropriate methods and materials" .

- *Process* evaluation, to serve *implementing decisions* – "making sure that the program is going as intended, identifying defects or strengths in the procedures" [6].

- *Product evaluation,* to serve *recycling decisions* – "a combination of Alkin's[24] progress and outcome evaluation stages" that serves to judge program attainments.

The CIPP model deals with products or outcomes not only at the conclusion of the program but also at various points during the program. Outcomes are then related to objectives; differences are noted between expected and actual results; and the decision maker decides to continue, terminate, or modify the program

C. Proposed Formative Evaluation Model for Innovation

Based upon CIPP model, the proposed evaluating items are identified in the followings.

Context Innovation Items

A prerequisite for evaluation is the development of a project plan with measurable objectives that are logically related to one another and to the goals and interventions defined in the project proposal. Stating goals can be done deductively or inductively. Deductively, stating goals results from translating the needs assessment into the mission of the institutional or organizational programs and activities. Inductively, stating goals results from assessing the institutional or organizational current programs and activities and determining the goals from those activities[12]. Harpel [12] writes, "Whereas the focus of the deductive approach is on the relationship between goal statements and students' needs, the inductive mode stresses the relation between goals and activities" (p. 26). Mager [25] also warns against confusing objectives with goals. Whereas goals are broad, objectives should be more specific and measurable.

Due to the importance of goal statements, everyone involved should be included in the formation and review of goals statements. An evaluation will best serve its clients when the goals and objectives have been negotiated with input from all relevant stakeholders. Unless using a goal-free approach, an evaluator should learn as much as he or she can about the background, goals, and objectives of the program being evaluated [26].

Harpel [12]identifies questions that test for the adequacy of goals:

- Does the goal address the needs of those who are served by the program?

- Does it relate to the activities of the program?

- Does it clearly identify the ideal result of the activities?

- Does the goal recognize the constraints of the environment (for instance, is it consistent with the purposes of the institution)

Curriculum Development structure is an element of the core business of curriculum innovation . Achieving the correct structure requires an investment in time, energy and expertise. This investment is important to maximize the educational experience for each student and to produce technology learners who are able to practice effectively, efficiently and with compassion in a world that is experiencing ever more rapid changes in knowledge, technology and cultural mores.

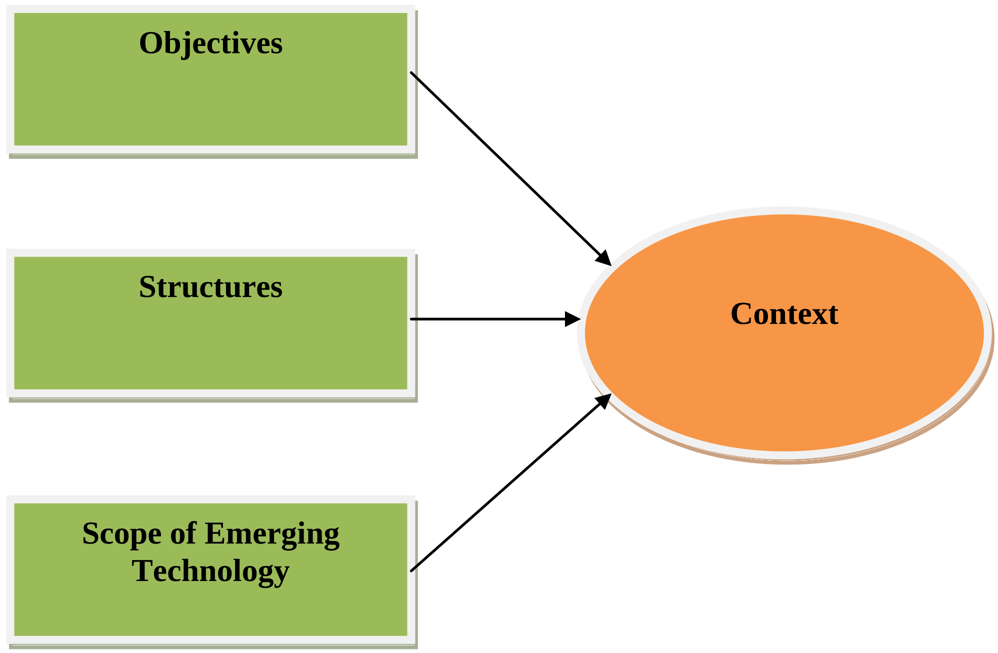

Fig. 1Measurement Model of Context Innovation

A curriculum has been defined as 'a planned learning experience'. In this way structuring not only determines the sequence in which subjects are presented, but also determines the method of teaching that fits a subject best and how the time available should be devoted to the different activities students need to master.

As learning takes place principally during self-study, time for self-study is essential. Not only should there be sufficient time for self-study, but it must also be appreciated that the scheduling and guidance of self-study activities is important. Self-study must be followed by effective evaluation, otherwise excessive or poorly directed self-study may lead to inadequate or inappropriate learning.

The curriculum should following certain structure in order to gain the essentials of the emerging technology.

According to the previous information about proposed items, a measurement Model of Context Innovation were shown in Fig. 1.

Input Innovation Items

Curriculum developers play an core role in controlling the quality of curriculum. In a curriculum design process, curriculum designers should make the decision about learning goals, content to be taught, learning experience selecting, lecturing style, learning activity, and even the grading system. Teachers who are developing this emerging technology curriculum would control the quality.

Evaluating the developers' ability about doing the curriculum design should focus on followings:

1. Understanding what is Technology Education
2. Understanding the goal of senior high education.
3. Owing the Knowledge and skill of developing emerging technology curriculum.
4. Understanding the learners' needs in technology education.
5. Understanding the learners' learning characteristics.

Curriculum development should be following concrete authorized resources for facts reference. The quality of resources used for curriculum developing and the quality of documents used for citation all should be reliable, authorized and trusted publicly.

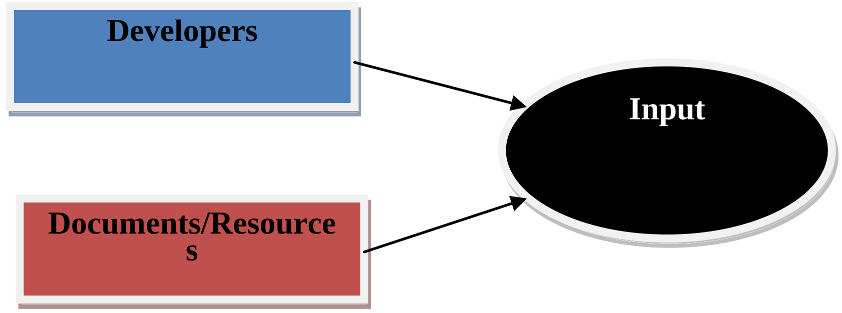

Fig. 2 Measurement Model of Input Innovation

According to the previous information discussed about proposed items, a measurement Model of Input Innovation were shown in Fig. 2.

Process Innovation Items

The qualities of processing in content selecting are evaluated under following factors.

- Filtering policy
- Theory foundations of technology education
- Logical relationship between curriculum goal and filtering order

The qualities of processing in learning experience ordering are evaluated under following factors.

- Correct entry level for the high school learners
- Theory foundations of sequencing
- Logical relationship between learning experiences
- Correct exit level for the high school learners

The qualities of processing in content describing are evaluated under following factors.

- Clear expression
  - Focus of paragraph statement
  - Direction of paragraph statement
  - Consistency of components in terms of curriculum values and goals
  - Reflection of learning needs
  - Reflection of teachers' assumptions
- Elements of technology
  - Functions of technology
  - Principle of technology
  - Impact of technology
- Learning Motivation
  - Their relationship to other topic & cross-topic
  - Ease of contextualization
  - Importance to the learner

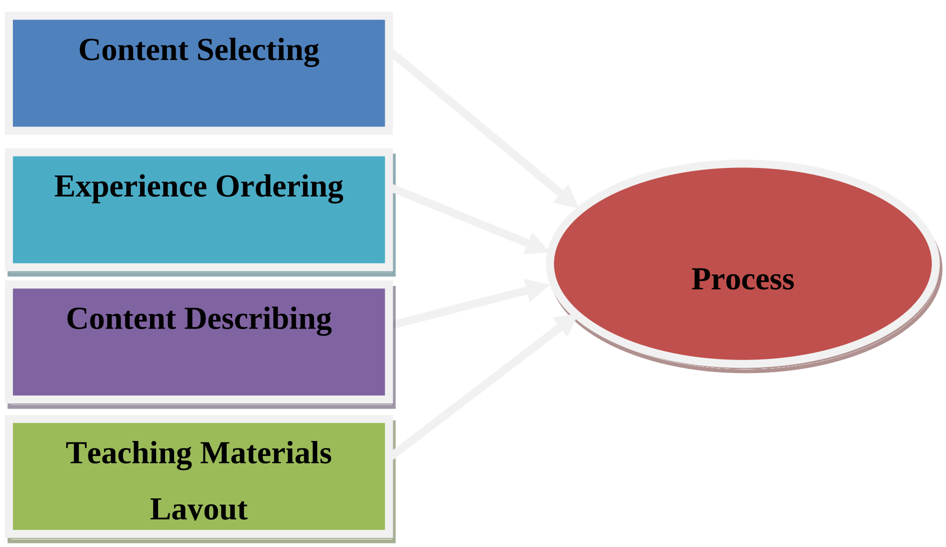

Fig. 3 Measurement Model of Process Innovation

The qualities of processing in teaching materials layout are evaluated under following factors.

- Visual experience
- Fitness between layout design and curriculum structure
- Face effectiveness
- Contracts between focusing information and general information
- Usability for visual experience
- Balance among text, table, figure and formula.

According to the previous information discussed about proposed items, a measurement Model of Process Innovation were shown in Fig. 3

Product Innovation Items

The qualities of output in integrating into current curriculum are evaluated under following factors.

- Integrating level in total learning hours
- Integrating level in learning schedule
- Integrating level in content
- Integrating level in editing style

The output qualities of curriculum development in feasibility are evaluated under following factors.

- Economy feasibility: Cost of teaching material
- Technology and system feasibility:
- Legal feasibility
- Operational feasibility
- Schedule feasibility.

The out qualities of creating emerging technology curriculum in emerging technology attraction are evaluated under following factors.

- Frequencies of emerging technology attraction identified in teaching materials
- Distributions of emerging technology attraction identified in teaching materials
- Explanations of emerging technology attraction identified in teaching materials
- Extensions of emerging technology attraction identified in teaching materials

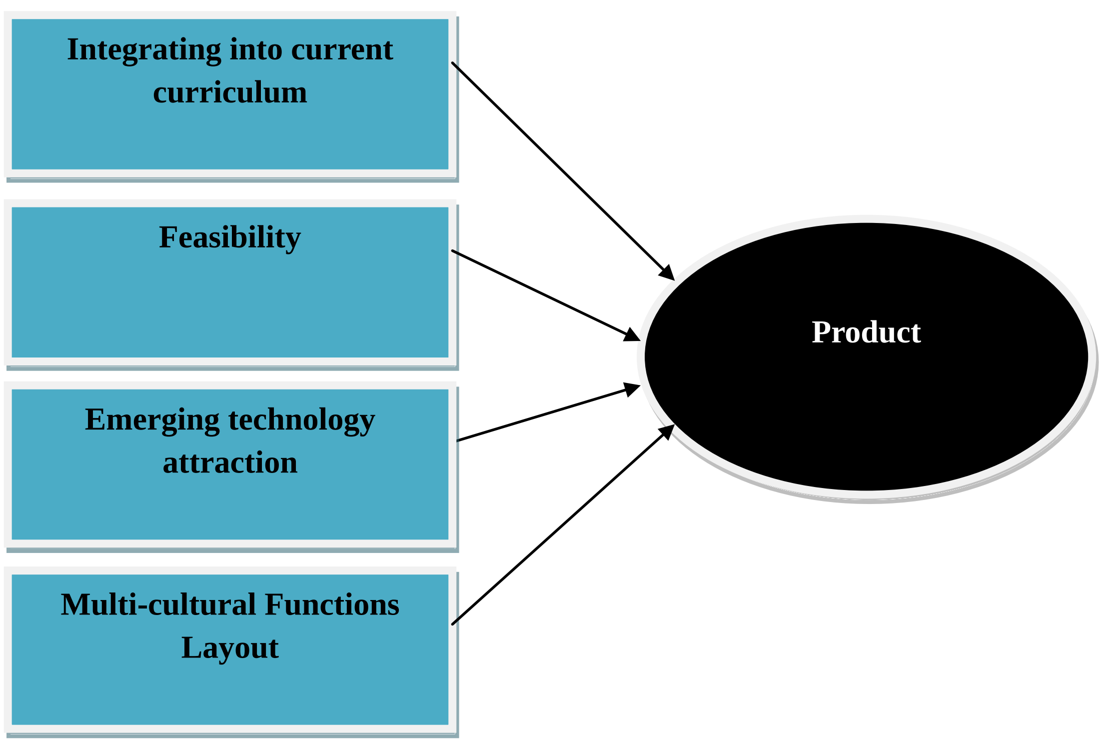

Fig. 4 Measurement Model of Product Innovation

The out qualities of creating emerging technology curriculum in multi-cultural functions are evaluated under following factors.

- Content integration: using examples and content from a variety of cultures and groups to illustrate key concepts, principles, generalizations, and theories in emerging technology.
- The knowledge construction process: teaching materials help learners to understand, investigate, and determine how the implicit cultural assumptions, frames of references, perspectives and biases of researchers.
- Prejudice reduction: To help learners developing positive and democratic racial attitudes.
- Equity pedagogy: facilitate learners from diverse racial, cultural, socioeconomic, and language groups. Using a variety of teaching styles and approaches that are consistent with the range of learning styles within various cultural and ethnic groups.

According to the previous information discussed about proposed items, a measurement Model of Product Innovation were shown in Fig. 4

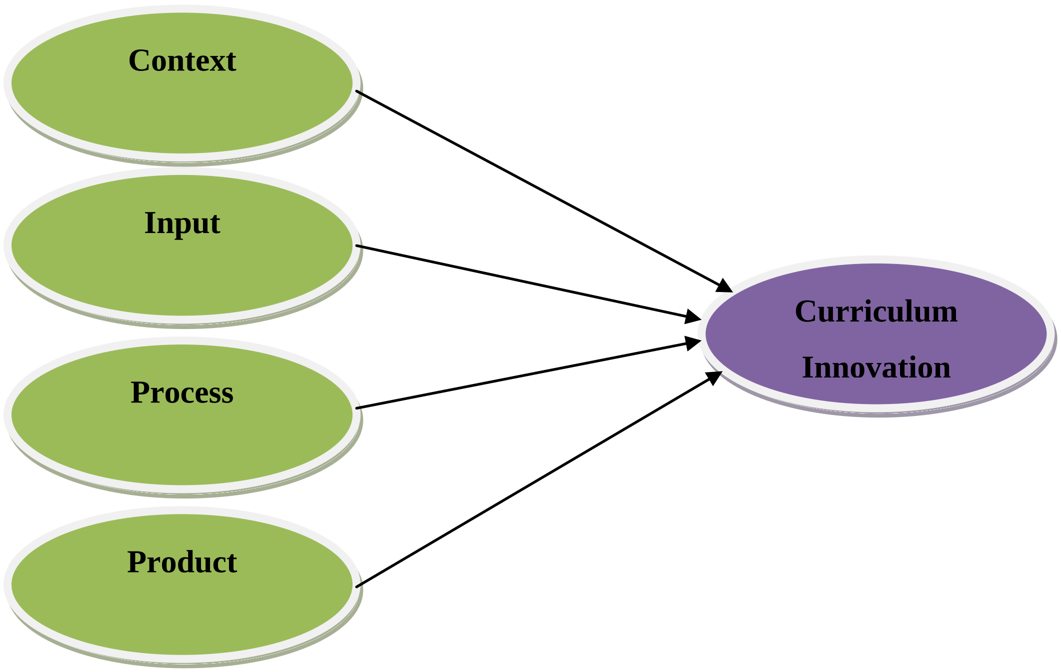

Fig. 5 A Conceptual Model of Evaluating Curriculum Innovation

I. Conclusion

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The purpose of this study was to create an evaluating model to measure innovation of the educational reform in a High School Emerging Technology Curriculum in Taiwan. A CIPP model was served as a foundation for both formative and summative evaluations.

The core concept is based upon innovation is the target of curriculum reform. In Taiwan, science educators are seeking ways of copying emerging technology. This study is a part of response to that call. This study suggested that innovation should be supported during the process but not only the end.

A proposed model was concluded according to previous discussions. In Fig. 5, the curriculum innovation could be contributed by context innovation, input innovation, process innovation, and product innovation. Each innovation evaluators were presented in measuring structure models accordingly.

According to the formative evaluation results from contest, input, process, and product stages, stack holders such as administrator, teacher, student, and parent could provide better efforts to maintain innovation. For better supporting science education reform, there is a need to find a systematic evaluation for innovation of curriculum reform. The identified structure was presented and discussed in response to the innovation evaluation.

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