Using the Context, Input, Process and Product model to assess an engineering curriculum

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ABSTRACT: In this article the authors describe the use of a Context, Input, Process and Product (CIPP) assessment model to design and develop an assessment matrix for an engineering curriculum. This research first discusses the CIPP theory and the development often used in educational circles of curriculum evaluation. Then, the CIPP assessment model for the engineering curriculum application at the present time is outlined. Finally, the researchers designed the matrix for CIPP assessment of the nano-technology curriculum and set up the validity analysis using an expert panel. The six expert members included two curriculum evaluative scholars and one expert from each of the following areas: nano-curriculum developer, engineering educator, educational researcher and vocational educator. After the researcher synthesised the expert panel's opinions, a revision of the CIPP assessment matrix for the nano-technology curriculum was completed using the suggestions of the expert panel. The matrix was provided for the evaluative use of the engineering education curriculum.

INTRODUCTION

In 1965 the United States passed the American Elementary and Secondary Education Act (ESEA). The Federal Government requested that the plan subsidised by ESEA had to use the Context, Input, Process and Product (CIPP) assessment method. CIPP is an abbreviation for the evaluations: Context, Input, Process, and Product (see Table 1). Context evaluation is used to choose the goal. Input evaluation is used to revise the plan. Process evaluation is used to guide the implementation of the plan. Product evaluation is used to provide the *inspection* determination [1][2].

Table 1: The four types of evaluation in the CIPP model. Adopted from [2].

	Context	Input	Process	Product
Aim	To diagnose problems and assess needs	To assess the possible changes	To ensure the suggested changes are carried out as intended, and to identify problems in implementation	To find out whether the instructional programme or idea actually made a difference
Method	Using methods such as classroom interviews, diagnostic tests, analysis of students' written work	Using methods such as literature search, visits to exemplary programmes, pilot trials, ideas from teachers in the field	Monitoring the change process, by observing and recording the activities that take place, and both the expected and unexpected results	Measuring changes in performance compared with students' work begun, including whether students have learned to transfer their knowledge to new problems. Measures can include interviews with participants, class tests, analysis of students' written work
Decision-making	To provide a basis for deciding on the changes needed	To find where there is the most support for change and to find out which solutions are most feasible	To help in fine-tuning the programme, and also to provide data which can be used later to interpret the impact of the change	To decide whether the changes should be continued, terminated or modified

Some researchers cited that current professional literature is also replete with articles regarding the classroom assessment process for individual courses [3][4] but, as a result of an overemphasis on classroom level assessment, other problems may be created [5]. Therefore, researchers want to thoroughly explore all the teaching stages using the CIPP model. To the present day, educational evaluators have always used the CIPP method, and derived benefits. It is a guideline providing a systematic structure for programme evaluation. Researchers describe CIPP in detail as follows [1][4].

Context Evaluation

Context evaluation deals with whether a curriculum includes focus, goals and curriculum objectives, meaning the organisational parameters. It also assesses the environment where evaluation takes place. The aggregate data and information gathered serve as a basis for curriculum decisions and the subsequent development of objectives [2]. Therefore, context evaluation includes: policy, surroundings, needs assessment, at the least.

Input Evaluation

Input evaluation involves an examination of the intended content of teaching (i.e. the skills or strategies the students learn), and it relates to deciding the resources and strategies used to achieve curriculum goals and objectives [6]. Besides, the purpose of input evaluation should support the choosing of resources. Therefore, input evaluation must include work plan, equipment, funds, and personnel resources, at the least. This item is used to revise the curriculum plan.

Process Evaluation

Process evaluation relates to the implementation of teaching. Based upon results of the pilot test or evaluation, it is necessary for process evaluation to describe the student’s need in order to reconstruct the program. Its goals are as follows: to forecast the mistake of designs; to provide information for decisions; and to assure the procedure of plans. By using process evaluation, it can provide regular feedback to the programme director. The researchers can understand the original plan, find the process, trace the change of plan, and provide the material to guarantee its efficiency and achievement. Finally, the ways to gather the data of process evaluation are multiple. These include the use of teacher behaviour measure, teacher rating measures, standardised achievement measures, expert referenced measures, and teacher-constructed knowledge and performance instructions [6][7].

Product Evaluation

Product evaluation is the assessment of teaching outcomes. The purpose is to carry out an instructional product evaluation, where the instructor tries to find out whether the instructional ideas actually made a difference [1]. The product evaluation could determine whether the curriculum should be modified, fine-tuned, or terminated and it also could evaluate the output of curriculum activities. Based upon the information related to background, input, process, and so on, it refers to comparing the difference between the outcomes and a predetermined standard or absolute standard. It can provide the reasonable explanation and consultation for decision-making. The goal is to evaluate the plan of curriculum in the endgame or particular gradations.

Matthews and Hudson used North Carolina as an example where teachers’ evaluation in engineering education should include the time-management of instruction, the management of students’ behaviour, teaching performance, students’ learning performance, the feedback of instruction, the influence of instructional surroundings, the performance of un-instruction and so on [8]. All the above items include systematic evaluation, formative evaluation and summative evaluation. As a result, the product evaluation is a very important element of CIPP.

THE APPLICATION OF CIPP MODEL IN ENGINEERING EDUCATION: USE THE MATRIX AS AN EXAMPLE

To implement the CIPP model in engineering education, researchers must first point out the application of the CIPP model. Then, as an example, use the nano-technology course of engineering education in a technology university [9].

Application of a CIPP Model

Finch and Crunkilton point out that as a contemporary curriculum was quite comprehensive, evaluation also must be comprehensive, taking into account the various aspects of curriculum initiation, structuring and operation [10]. The diagram presented in Figure 1 serves to illustrate various aspects of evaluation that relate to curriculum initiation, structuring, and operation [6].

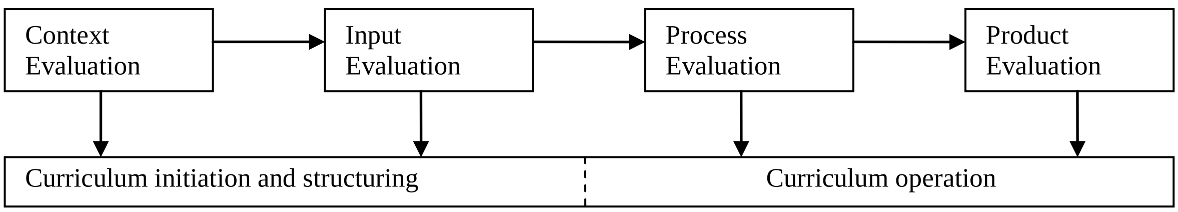

Figure 1: A framework for curriculum evaluation. Adopted from [6].

Based upon the framework of curriculum evaluation, context and input evaluation need to be sketched before developing and designing the curriculum. The process and product evaluation refer to the methods and results of instruction in teaching. The following are representative of the numerous curriculum questions one might seek to answer as part of the CIPP model (see Table 2).

Table 2: The matrix of CIPP representative questions. Adopted from [10].

CIPP	Representative questions
Context Evaluation	Should the curriculum be offered? What student population will the curriculum serve? What business or industrial population will the curriculum serve? What content will be included in the curriculum? What goals should the curriculum have? What objectives will be used in the curriculum?
Input Evaluation	What curriculum materials might be most useful in a particular educational setting? Which materials are most acceptable to teachers and students? How might individualised instruction be best implemented? What are the relative effects of different materials on student achievement?
Process Evaluation	How well are learners performing? What is the quality of instructional and support personnel? What are the costs associated with operating the curriculum? To what extent are students satisfied with their instruction? Which (if any) of the curriculum components are deficient?
Product Evaluation	What is the mobility of former students? How satisfied are former students with their position? How do employers view the performance of former students? How adequately is the curriculum preparing individuals for job entry?

Assessment Matrix of the CIPP Model for a Nano-Technology Curriculum

Olds and Miller [11] provided an assessment matrix for evaluating engineering programmes, and recommended the following steps to develop a program assessment plan:

1. Identify program goals consistent with institutional goals and the needs of internal and external stakeholders, including accrediting agencies such as ABET.
2. Develop programme objectives and performance criteria for each programme goal.
3. Decide the programme curricular and co-curricular activities that will address each object and when assessment data will be objective.
4. Determine the best methods for assessing and evaluating each objective and when assessment data will be collected.
5. Report results to stakeholders and use feedback to improve the programme and assessment process itself.

Researchers incorporated the CIPP model with the nano-technology curriculum, and listed every step that should be done in detail. Then, the nano-technology curriculum teacher provided the feedback about the matrix through a comprehensive interview. Researchers used the MAXqda, qualitative data analysis software to code the theme/categories of text in order to establish coding reliability. The first coder agreed with 39 categories of concept subject in total. The other coder agreed with 35 categories of concept subject in total. As a result, the two coders completely agreed with 30 categories of concept subject in total. According to the results of the computed formula [12], the intercoder agreements of the two coders was 0.8108, coding reliability was 0.8955, and indicated the coding reliability classification was sound.

After the interview with the nano-technology curriculum teacher was completed, the teacher provided some suggestions about the matrix of the CIPP model for the nano-technology curriculum. After each interview response, the following coding was presented: “Li” in brackets is representative of the interviewee and the number, such as 042, indicates the coding number of the response.

Merit:

> *This matrix of CIPP can assist the teacher to adjust his/her instructional content, and I can follow the matrix model to prepare my teaching. Besides, I can get the feedback from the assessment mechanism in time during my teaching process. This matrix of CIPP can assist the teacher to analyse students’ background and their content knowledge before teaching, too (Li, 042)* .

Some possible problems:

1) The teacher is easily disturbed by the assessment mechanism during the instruction; 2) It is more difficult to interview students during the process of teaching; 3) How about the teacher's desire to accept this CIPP model assessment? 4) Generally speaking, the teacher is not willing to change his instructional or evaluative model (Li, 045).

The following revisions to the existing Matrix statements were suggested by Dr Li, the nano-technology curriculum expert:

In the Matrix under Context Evaluation/CIPP model implement in the curriculum of nano-technology, please add: *The students include their origins, degrees, grades, and population*. In the Matrix under Input Evaluation/CIPP model implement in the curriculum of nano-technology, please include: *Funds: How much money is spent on this curriculum? and, teaching assistant, etc?* Finally, in the Matrix under Input Evaluation/CIPP model implement in the curriculum of nano-technology, consider: *How much money does this curriculum cost (capital expenditure and administrative expenditure) when the teacher implements the programme?*

As the result of the Expert Panel review, the following comments were added and underlined in the final Matrix shown in Table 3. In the Matrix under Context Evaluation/CIPP model implement in the curriculum of nano-technology, the following should be added: *8. What is the basic theory for curriculum development? 9. What is the academic achievement level of the students over the review period?* and, *10. What are the demographics and historical background for the school?* In the Matrix under Input Evaluation/CIPP model implement in the curriculum of nano-technology, *5. How do parents support the goals and content of the nano-technology curriculum?*, should be included. In the Matrix under Process Evaluation/CIPP model implement in the curriculum of nano-technology, the teacher satisfaction concern should be addressed with: *8. How satisfied are teachers with themselves in the process of teaching?* In the Matrix under Product Evaluation/ CIPP model implement in the curriculum of nano-technology under formative and summative evaluation, please add the following: *Formative evaluation: 5. Do the students already achieve the level of all ability indexes at every stage of the learning process? Summative Evaluation: 1. What is the ability index established for summative evaluation?*

This matrix was reviewed by curriculum experts, engineering education experts, curriculum experts and technology education experts. They thought this matrix had several special purposes for teachers' instruction. Researchers reported all six experts' opinions as follows:

- *This matrix can be described clearly. The teacher also obtained essential information of the curriculum which can establish the foundation of the instruction.*
- *Context Evaluation: It can point out the instructional goals and the related theoretical foundation clearly.*
- *Input Evaluation: It can remind teachers of which resources should be prepared and how to make use of them well, so as to achieve the goals of curriculum.*
- *Process Evaluation: It can explore the questions during the process of teacher's instruction and get regular feedback from the assessment mechanism. Finally, it can become a dynamic assessment process.*
- *Product Evaluation: Through it, the outcome of education can be clearly understood, and the index of curriculum assessment can be constructed.*

Thus, the validity of the CIPP Matrix was established by the expert panel. The finalised CIPP Matrix for nano-technology is found in Table 3.

CONCLUSIONS

The CIPP assessment Matrix was designed mainly to emphasise the importance of the teaching process. This study first discussed curriculum assessment and the CIPP model. Then, researchers decided to apply the CIPP assessment model to a nano-technology curriculum in engineering education. After interviewing the engineering educational teacher, the nano-technology curriculum CIPP Assessment Matrix was revised and sent for review by the expert panel. From the panel's suggestions and feedback, researchers integrated the experts' opinion into the final CIPP Assessment Matrix for a nano-technology curriculum. The next step is for the researchers to implement the CIPP Assessment Matrix for a nano-technology curriculum. The researchers hope that the Matrix can become the reference for the design of relative engineering curricula, in order to improve the teaching quality of engineering education.

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REFERENCES

1. Nicholson, T., Using the CIPP Model to Evaluate Reading Instruction. *J. of Reading*, 32, **4**, 312-318 (1989).
2. Stufflebeam, D.L., *The CIPP Model for Program Evaluation.* In: Madaus, G., Scriven, M. and Stufflebeam, D.

(Eds), Evaluation Models: Viewpoints on Educational and Human Services Evaluation. Boston, MA: Kluwer-Nijhoff Publishing, 117-141 (1983).
3. Doyle, J.M. and Wood, W.C., Principles course assessment, accreditation, and the depreciation of economic knowledge. *J. of Educ. for Business*, 80, **3**, 165-171 (2005).
4. Sheppard, S., Johnson, M. and Leifer, L., A model for peer and student involvement in formative course assessment. *J. of Engng. Educ.*, 87, **3**, 349-354 (1998).
5. Bailey, M., Floersheim, R.B. and Ressler, S.J., Course assessment plan: A tool for integrated curriculum management. *J. of Engng. Educ.*, 91, **4**, 425-434 (2002).
6. Finch, C.R. and Bjorkquist, D.C., Review and critique of context and input measures in evaluation. *J. of Industrial Teacher Educ.*, 14, **2**, 7-18 (1977).
7. Wolansky, W.D., *Evaluating Student Performance in Vocational Education.* Ames, IA: Iowa State University Press (1985).
8. Matthews, J.M. and Hudson, A.M., Guidelines for evaluating parent training programs. *Family Relations*, 50, **1**, 7-86 (2001).
9. Tseng, K.H., Chang, C.C., Chen, W.P. and Lou, S.J., The use of a computer-mediated environment to promote learning performance through concept mapping in a nanometre course. *World Transactions on Engng. and Technol. Educ.*, 8, **1**, 50-55 (2010).
10. Finch, C.R. and Crunkilton, J.R., *Curriculum Development in Vocational and Technical Education*. (4th Edn), Needham Heights, MA: Simon & Schuster (1993).
11. Olds, B.M. and Miller, R.L., An assessment matrix for evaluating engineering programs. *J. of Engng. Educ.*, 87, **2**, 173-178 (1998).
12. Berelson, B., *Content analysis in communication research*. Illinois: The Free Press (1952).

Table 3: The final CIPP assessment matrix for a nano-technology curriculum.

CIPP	Context evaluation	Input evaluation	Process evaluation	Product evaluation
Purpose	1. To define the context (e.g. policy, surroundings) of implementation plan. 2. To ensure the needs assessment of context. 3. To ensure and describe the issue or problem of needs assessment. Therefore, context evaluation includes three basic elements: policy, surroundings, and needs assessment.	1. To ensure and evaluate the feasibility of input evaluation system. 2. To ensure and evaluate the implementation strategy. 3. To ensure and evaluate the design, budget, and schedule of implementation. Therefore, input evaluation includes four basic elements: plan, equipment, budget and human resources.	1. To ensure or predict a deficiency in the designed procedure. 2. To ensure or predict a deficiency in the process of implementation. 3. To maintain a record of teaching event and activity.	1. To combine the information of purpose, context, input, process with product. 2. To decide the situation of curriculum implementation and the situation including whether the curriculum should be continued, terminated, revised, or redesigned. 3. To evaluate and explain the plan of curriculum in the endgame or particular gradations.
Method	1. To use systematic analysis. 2. To survey. 3. To review the literature. 4. To interview. 5. To do a diagnosis examination. 6. To use Delphi Technique.	1. To write a checklist, including human resources, material resources, strategies, flowcharts and action plans. 2. To analyse the benefit, efficiency, cost. 3. To find a successful plan by reviewing the literature. 4. To use the experimental research.	1. To trace the possible barriers during the activity. 2. To keep highly aware of the unexpected barrier. 3. To keep continuing interaction with the planning staff. 4. To observe the teaching activity.	1. To make an operational definition of students' outcome evaluation and their achievement level (or standard). 2. To measure the outcome of students. 3. To collect the results evaluated by the staff who related to the curriculum plan. 4. To analyse or discuss the evaluation results of curriculum by using qualitative and quantitative methods.
CIPP model implemented in the curriculum of nano-technology	*1. What is the background of students who would take the course? (The students include their*	• Work plan: What is the table or list for the curriculum plan. • Equipment: Which software and hardware resources does this	1. How satisfied are the students with their teacher in the process of teaching? 2. What does the teacher think of the	• Formative evaluation: 1. How satisfied are the students with curriculum content? 2. How satisfied are the students with the teacher's

	origins, degrees, grades, and population). 2. How important is the curriculum during this time? 3. How many students take this curriculum? 4. Which department does the curriculum prepare for? What kind of job preparation is the curriculum expected to provide students with? 5. What goals should this curriculum include? 6. What instructional goals should be in this curriculum? 7. What should the instructional content be in this curriculum? *8. What is the basic theory for curriculum development?* *9. What is the academic achievement level of the students over the review period?* *10. What are the demographics and historical background for the school?*	curriculum need to use? • *Funds: How much money is spent on this curriculum?* • Human resources: What kind of teachers with specialised backgrounds does this curriculum need? Which specialised personnel support is needed during the process of practice in the laboratory (e.g. *technician, teaching assistant, etc)?* • Others: 1. What pattern (e.g. textbook, handout, technical data, etc) of the teaching material is most helpful to the student? 2. What content of the teaching material would be accepted by most teachers and students? 3. Which teaching strategy should be used in this curriculum? 4. How many units of the teaching activity should be included in the entire curriculum? Are there any further teaching lessons or activities designed for each unit or every week of curriculum? *5. How do parents support the goals and content of the nano-technology curriculum?*	students' academic performance in this classroom? 3. What is the support quality from the administrative division of the university authorities for teachers' instruction? *4. How much money does this curriculum cost (capital expenditure and administrative expenditure) the university when the teacher implements the programme?* 5. Are there any barriers (e.g. not sufficient equipment) during the teaching? Which barriers? 6. Are there any deficiencies in the process of teaching? 7. Are there any differences of teaching goals and content between the ideal and implemented curriculum? Which parts of the curriculum have been adjusted? *8. How satisfied are teachers with themselves in the process of teaching?*	instruction? 3. How satisfied are the students with their learning situation? 4. Is this curriculum helpful for the student getting a job? Why? *5. Do the students already achieve the level of all ability indexes at every stage of the learning process?* • Summative evaluation: 1. What is the ability index established for summative evaluation? 2. How to revise the curriculum plan after evaluating, for the teacher, the whole curriculum at the end of the semester? 3. Quantitative evaluation: What is the final overall academic achievement of students? What are the results for students evaluating the teachers' instruction? 4. Qualitative evaluation: What about the learning process of students by interviewing teachers or students and through students' portfolio evaluation at the end of semester? • Does the teacher have any other opinions about the students' academic performance during class?