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Applying the NIMSAD Framework to Evaluating IA Education Projects

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Abstract – This paper applies the NIMSAD framework to the evaluation of IA education projects. The framework considers elements relating to the education process, the education practice, and the educators as project teams. It is proposed that the evaluation of the above elements takes place at a minimum of three time periods using the criteria of efficacy, efficiency and effectiveness. The framework recognizes the importance of the human element and provides a holistic process to evaluating IA education projects. The generic nature of the framework allows its adaptation to other curriculum development, IT and security related projects and research.

Index terms: information assurance education, IA projects, curriculum evaluation, efficacy, efficiency, effectiveness, framework, methodology

I. Introduction

Evaluation is the process of ascertaining the value of an object or project by careful appraisal. An appropriate set of evaluation criteria must be applied in order for the evaluation process to produce results which give a realistic reflection of the project achievement. In an education project the adopted evaluation framework needs to be relevant to the project under assessment, and should contain analysis of all relevant aspects of the project under investigation and intervention.

This paper presents a model for evaluating information assurance (IA) education projects based upon the NIMSAD framework. The framework is holistic (systemic in nature) and designed for application to not only curriculum development but also to broader IA education projects. It has been used in action research as such the framework embraces a much broader perspective than the evaluation processes of curriculum for professional accreditation purposes.

There is always confusion between the use of a framework and methodology. A methodology is simply an explicit way of structuring one's thinking and actions, and always implies a time-dependent order of thinking and/or action stages. A conceptual framework is a meta-level model through which a range of concepts, models, techniques, including methodologies can either be clarified, compared, categorized, evaluated and/or integrated A framework is static higher level model which provides a structure to help connect a set of models or concepts [1]. The role of a framework is to identify 'what' aspects to focus on while it is the role of a methodology to select which 'whats' and 'how' to structure the transformation from one state to another.

The scope of this paper is to provide a comprehensive framework for evaluating IA education projects. A detailed methodology for undertaking such an evaluation is not within the scope of this paper, but readers are directed to the work of Melissa Dark [2],[3] for a more in-depth set of guidelines for evaluating IA curriculum.

II. The NIMSAD evaluation framework

The NIMSAD framework was first constructed as a meta model for evaluating action research practice and methodology structure and practice in problem solving situations. The original framework is illustrated in Figure 1 and consists of four elements – the 'problem solver(s)', the perceived 'problem situation', the problem solving process, and evaluation of three elements at three different time periods.

The original NIMSAD framework presented a useful way for evaluating IT projects, however the nature of the framework is generic and has allowed its application to a much broader range of fields.

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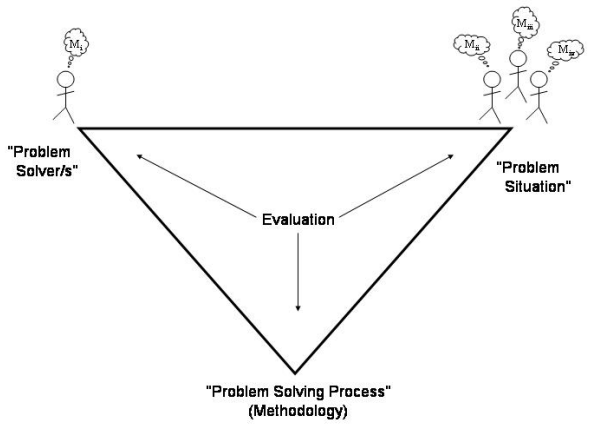

Figure 1: NIMSAD and Problem Solving [1]

A more generic view of the framework in Figure 2 allows one to understand the links between the roles and practice of 'situation and methodology context', 'problem solving process and the methodology that will help to structure that process' and problem solver and the methodology user'.

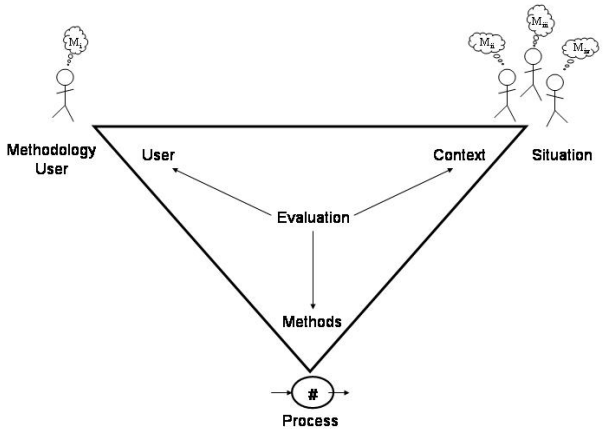

Figure 2: NIMSAD generic framework (after Jayaratna, 1999[1])

A. The 'Problem Situation' (Methodology Context)

The situation is the context in which the methodology user engages to undertake the process. In any transformation or change, there will be at least two 'states' for any situation and outcomes – the current situation and the desired situation. The methodology user may choose, modify, adapt or construct a methodology to structure their problem solving process in order to move the current situation to the desired situation. In this context a methodology has to help its user to conceptualize the 'current and desired states' for a given situation.

B. The Problem Solving Process (Methodology)

This is essentially the processes involved in formulating a problem, designing solutions and implementing designs. In an expanded form, this process consists of 8 conceptual stages a problem solver will go through in arriving at a resolution. The structure in which these stages will be conducted may be sequential, parallel, or cyclical and will be determined by a particular methodology. They will help to perform 'diagnosis', a projected model of one's understanding of the current situation, and 'prognosis', a projected model of one's understanding of the desired situation. The stages help to structure the mind in the attempts at moving the current situation to the desired situation. This process may take place in any order but will be supported by methods, techniques and tools provided by a particular methodology in practice. If a methodology is to help solve problems then it must provide

- a series of steps,
- an order in which to carry out the steps (e.g. sequential, cyclical, parallel but not random),
- how to perform those steps (these are the techniques and methods), and
- most importantly a rationale as to why those steps should be carried out in the order suggested, using those particular techniques and methods.

C. The 'Problem Solver(s) (Methodology Use(s))

Each individual or a methodology user will have unique 'mental construct' which will guide their understanding and actions in the situation under change. This 'mental construct' is characterized by their knowledge, skills, experience, values, and needs[1] and forms the basis through which they will view of the world. This set of criteria combines to form an individual's 'weltanschauung',[2] (W) or worldview and as such may not be a comprehensive view or logical set of judgments. However, it is this 'W', that will help to underpin an individual's action in everyday situations [5].

D. Evaluation (Learning focus)

Because models, methods, techniques, methodologies and the 'mental construct' of the Facilitator/s are incapable of addressing the complexity of any particular situation,

[1] See Jayaratna, 1999 [1], page 64
[2] See Checkland & Scholes, 1990 [4] for more information on the 'weltanschauung'

there is a need to evaluate all three elements in an integrated ('systemic') way in order to make the learning process more holistic. If change in a situation is to occur, or an objective is to be achieved, then the three elements have to interact dynamically over a time period, and if learning is to take place then it has to focus on evaluation of all the three elements during a minimum of three time intervals - before (t_0), during at one or more time intervals ($t_1 \ldots t_{n-1}$), and after (t_n) intervention.

1. Before

Evaluation is carried out before the intervention (t_0) to allow an initial assessment of the situation, to define a 'desired state' as envisaged by the client, their level of commitment, to consider the relevance and validity of the client's request, to decide upon an appropriate methodology to employ, and to identify any required training needed in the use of the methodology. Evaluation of a range of methods, techniques, methodology are undertaken to choose the best intervention strategy and how to structure that intervention in the light of information gained from the situation. Evaluation of selves are conducted to ascertain what knowledge and skills are required, what self preparedness is necessary for the intervention.

It is the combination of these three elements that determine the nature of initial intervention. For example, given the client's needs the most appropriate methodology to match the needs and the culture of the situation may be X but if the interventionists (problem solvers) are not familiar with the intricacies of the methodology they may modify or even abandon the use of that methodology. This is why it is important to have the evaluation and lessons gained from such a process for learning and development.

2. During

Evaluation is undertaken during the intervention ($t_1 \ldots t_{n-1}$) due to the dynamic nature of any situation under study and the changes the interventionists themselves may go through. This process includes ascertaining the level of continued client commitment, changes in priorities, changes in direction and politics of the situation. In addition there needs to be continued assessment of the appropriateness of the chosen methodology, steps, models as well as the changes required. Evaluation should also be directed towards selves in order to understand our own learning i.e. emotional changes, assessment of mistakes and recovery needs. These evaluations should be on going and should take place at least once during the intervention period.

3. After

The final evaluation is undertaken after the intervention (t_n) to assess lessons from engaging in the change. This evaluation will assess whether the project was completed on time and within budgets, whether the solutions operate as intended and whether as a result of the solutions the 'problems' are resolved. There are also lessons to be abstracted about models, methods, techniques, methodology, about their use, modification, construction and future development. The most important lessons to be learned are what lessons can be abstracted about ourselves. What do we know about our values, our behavior, weaknesses, areas for development etc.

We also can apply three criteria of efficacy, efficiency and effectiveness to evaluate the three elements of the framework. These criteria were developed within 'Soft' Systems Methodology [5] as a way of structuring learning. These will be elaborated later in the paper.

III. NIMSAD APPLIED TO IA CURRICULUM EVALUATION

If we are to use the NIMSAD framework and the philosophy upon which it is based for IA curriculum or project evaluation, then the process can also be conceived as problem solving, in this case as a development project. The problem here would be 'what' kind of curriculum and 'how' can that be developed. If the curriculum has already been developed then the framework could be used in the evaluation of after intervention stage. The difference between correcting a 'situation' to match expectations and deriving a new expectation and making a move towards that expectation are similar in nature (i.e the difference is primarily teleological). Both problem-solving and curriculum development are human activities which can be considered to have teleological characteristics, which in each case, can be explored as a process of enquiry.

In the context of the NIMSAD framework, the analysis of the educator's 'mental constructs' (M_i) is crucial to their understanding of how they select, modify or construct a methodology that was appropriate to the educational curriculum development and implementation as well as for learning about themselves. The educator's' mental construct' is derived from experience, values, ethics, education, and thought structuring devices (such as methodologies). Since every individual is unique, then critical self-reflection on how that individual's 'mental construct' influences their actions is critical for self development and to help with a holistic understanding of the entire situation under study. Every situation where a methodology is used is unique. This uniqueness is brought about by the characteristics of the educator, the

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current and desired education curriculum in operation and how the process was structured using a methodology.

It is the integration of the three elements, the context, the methods and the educator's 'mental constructs', that help achieve success. Because the methodology-in-action often involves dealing with complex human situations (power, roles, and inter-personal aspects), the exploration of the 'mental construct' is of critical importance to understand the impact of situational issues on their thinking.

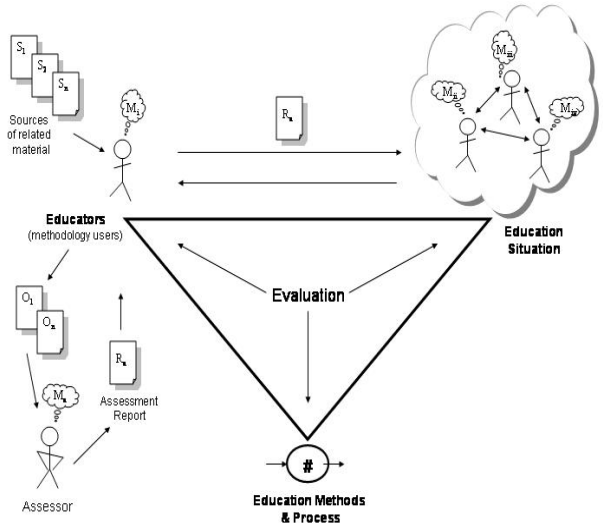

Figure 3: NIMSAD in IA Education

IV. The Education Output ($O_{(1)}..O_{(N)}$)

The primary beneficiary of IA curriculum development will normally be those who go through that curriculum i.e. the students. Clients who sanction the development to be undertaken, or whose views are sought in order to generate a curriculum also benefit because their goals are realized in the use of the curriculum. The clients will expect that the output (curriculum) matches their criteria for acceptance in return for the financial assistance and facilities they provide. They may not ask for the justification of the self learning process used in arriving at the desired output because of their trust in the competence and qualifications of the development team.

However, where the development team are seeking acceptance of their output as a valid curriculum or establishment of their status as IA educators by their professional community, then they have to produce a set of additional output (dissertation/theses) based on the lessons they abstracted for the assessors who are expected to pass judgment on the content, methods used and the justification provided. In academic (education output) there is a very clear expectation for the educators to justify their report content, process used and lessons learned. Part of this will involve situational issues, interactions with students, environments, facilities provided, the choice of teaching and learning methods used as well as the validity in the use of methods in practice. A wealth of literature is available on teaching methods in IA and the success and failure of IA education processes and projects[1]. The security educational content may have to be linked with a recognized IA body of knowledge[2]. What is missing from this evaluation is the third component i.e. critical self reflection. This means the lessons learned by educators about their own selves.

A. IA Education Reference Sources ($S_{(1)}..S_{(n)}$)

A further requirement of the output $O_{(n)}$ is the relationship of its content and methods to other sources of related IA and education materials, $S_{(1)}..S_{(n)}$ in Figure 3. This will be an additional requirement for the justification process. The educators need to demonstrate -

- the relevance of the IA content,
- their ability to critically evaluate and learn from the concepts, frameworks and methods used, and
- comparative and critical study of the results. They will be required to justify as to why they adopted or adapted others methods etc.

In essence the output must make reference to previously published findings against which the new findings can be contrasted. These previously published results could focus on IA knowledge or skill levels attained, identified IA knowledge and skill needs, appropriateness of teaching and learning methods to IA, reflection of lessons learned in IA curriculum development and implementation, and the like. The assessors must, therefore, rely on the content of this output and the published literature in order to assess the validity of the processes used, content and end product produced as a result. The assessors need to establish not only the validity of the output, but also the relevance of the content and methods, justification of the selection of the methods, their use in practice, the validity of their findings, their standing against other published findings as well as the assessment

B. Evaluation of the assessment process

As can be observed, the role of the assessor is crucial to the evaluation of the development process and the related output and to enable the educators to attain credibility

[1] For example, see proceedings of previous CISSE and WISE conferences

[2] For example, see the Report on Information Assurance Curriculum Development, by Melissa Dark and Jim Davis, 2002 [3]

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within the IA education community. The 'mental construct' $M_{(a)}$ of the assessors is then crucial for the establishment of the credibility of this wider process.

The reason for the inclusion of the assessors in the framework is to alert the assessors to the need for the separation of intellectual and political issues. In some situations the educators' mental construct may be influenced by the position and role of the assessors based upon the assumptions the educators may make about the political needs of the assessors. This then influences what theoretical material and references they may make in their theses or dissertations. This is particularly pertinent where projects may be undertaken to produce the output desired for political purposes or to fulfill a political need. It is this process that needs to be monitored and developed in order to ensure the value of education received by the ultimate client of the curriculum process.

V. Criteria for Evaluation

We now wish to explore the three main criteria for evaluating IA educational projects. They are efficacy, efficiency and effectiveness. These criteria can be applied to the IA education situation, the IA education process, and the IA educators - the three main elements of the NIMSAD education model as part of the evaluation process. In general terms, efficacy considers whether the proposed project is feasible and is capable of delivering output against the specific purposes, it can be completed, and whether it can actually work. Effectiveness measures how well the end product achieves the objectives, and efficiency measures how well resources are used in delivering the output against the objectives.

A. Efficacy

Efficacy in an IA educational context relates to whether the curriculum development project or solutions proposed can indeed meet the objectives set for the curriculum. Secondly, will that curriculum development project produce the intended IA educational material, teaching and learning methods and assessment methods appropriate for a curriculum of this type. In addition, this evaluation can also be extended to consider whether the models proposed will transform students who go through the curriculum into 'good' IA professionals. Also if the project involves changing traditional teaching to IT based learning then questions could be asked whether the proposed model can actually produce those learning goals Examples would be the configuration of hardware and software in a teaching laboratory for testing or research. The ideal teaching laboratory may wish to emulate a typical network environment as in a business setting, or a specialized isolated network configuration for teaching intrusion detection, honeynets or firewall hardening. Pilot studies are often an astute and judicious approach to testing efficacy in an IA education setting. However, in the experience of the authors reproducing the desired network environment and the production of 'normal' traffic is often difficult to achieve in an educational setting focused on IA. Basically, this is a logical judgment of the proposals to ascertain whether the proposals are worth pursuing or worthy of investment etc.

B. Effectiveness

Effectiveness is measured by evaluating how well the end product achieves the stated objectives. This can only be done once the solutions are in operation and running successfully. In this context, if the new IA curriculum produces graduates of equivalent quality or better then the new curriculum based on IT can be considered to be effective. Therefore effectiveness measures need to be set before the development of the curriculum so the results can be measured after the operations. If not, those who are engaged will set measures that are feasible rather than desirable [5].

C. Efficiency

Efficiency is measured by studying the result of increases or decreases in the level of given resources used for achieving the objectives. The most common measure of efficiency is a ratio calculated by dividing the output by cost (resources used), however other factors can also be considered. In general terms, efficiency is achieved where processes applied uses less resources to produce the same or greater output, or the same amount of resources to produce increased output.

For example, let us assume that the main objective of a specific IA education project is to produce a given number of graduates with a set level of security skills utilizing a given set of resources. Efficiency would be thus achieved in the project if –

> The given number or more students graduate, with the set level or more security skills, utilizing the same or less resources.

One must remember that it is possible to achieve higher efficiency without effectiveness and higher effectiveness with less efficiency. It is important, therefore, that project objectives be specified in a manner which allows measurement for determination of efficacy, effectiveness and efficiency.

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VI. Conclusion

Undertaking curriculum development can be considered as a problem solving project. An evaluation framework such as NIMSAD which has been used for evaluating methodology structure, content and practice, and action research can be used in curriculum evaluation provided that process is considered as a similar project. Additional criteria of efficacy, efficiency and effectiveness can be utilized in projects that seek to measure or compare results with traditional curriculum development or operations. In addition, the use of the framework enables the evaluation of the assessment process of educator's own development as well as their output. Finally the framework can be used in the evaluation of the suitability of assessors themselves.

VII. References

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