

# A Design for Generating Personalised Feedback in Knowledge Construction

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**Abstract.** As the learning paradigm shifts to a more personalised learning process, users need dynamic feedback from their knowledge path. Learning Management Systems (LMS) offer customised feedback dependent on questions and the answers given. However these LMSs are not designed to generate personalised feedback for an individual learner, tutor and instructional designer. This paper presents an approach for generating constructive feedback for all stakeholders during a personalised learning process.

The dynamic personalised feedback model generates feedback based on the learning objectives for the Learning Object. Feedback can be generated at Learning Object level and the Information Object level for both the individual learner and the group. The group feedback is meant for the tutors and instructional designer to improve the learning process.

## 1 Introduction

As the learning paradigm shifts to a more personalised learning process, users (learners, tutors and instructional designers) need dynamic feedback from their knowledge path. Learners appreciate real time feedback that helps them improve. Knowing how the students performed in a particular learning scenario is a responsive communication to both tutors and instructional designers. It is particularly emphasised by the learning theories [1] as the important instrument used in a learning process where progress, improvements and achievements are provided in the real-time [2]. The feedback offered to the learner should motivate them rather than demoralise their efforts to learn. Learners who fail to achieve particular learning objectives should be encouraged and advised on achieving the learning objectives.

Feedback generation is considered as an important functionality in e-learning. Many Learning Management Systems (LMS) [3] contain the functionality for offering feedback. For example, the comments and suggestions are pre-defined and associated with the individual assessment questions. The feedback is then generated by consolidating the predefined information after the learner has been assessed [4]. To provide this kind of feedback would satisfy a degree of success for individual questions, but it is difficult to customise feedback according to individual learners' performance and to support continuous improvements during the learning process. Furthermore, there is no mechanism for the feedback to reflect the learning objectives

set for the overall learning content and achievements at different learning stages. On the other hand, it is impossible for the users, i.e., content designers and tutors, to receive feedback on the quality of learning content designed and delivered. Therefore an effective method is needed that can enhance dynamic generation of feedback for the individual learner, tutor and instructional designer about the learning process.

This paper presents a method for generating personalised feedback. This method considers learning objectives as the criteria for measuring achievements at various learning stages. Feedback should then be generated according to individual users' role and achievements within a learning process. The technical components of the method can be incorporated in the LMS for enhancing the capability of facilitation.

## 2 Learning Process and Information Required

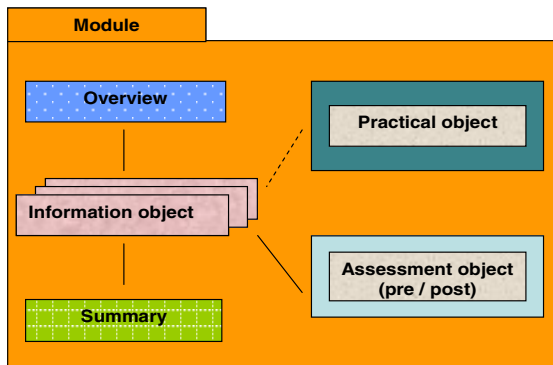
Learning as a process of knowledge construction involves different users (learners, tutors and instructional designers) participating in several activities like content authoring, assessments, application and feedback generation. The different users aim at achieving different goals depending on the activities carried out within the learning process. As Constructivism states, learners play an active role and take on responsibility to construct their own knowledge and meaning [5], [6], [7]. The learners will act in different ways based on their own judgement hence make meaning out of the learning process. The learners prefer different ways by which information is presented to them because it affects how they act on it. The individual learner's actions become the basis of what feedback should be generated for them. The constructivist theory has been used in the design of constructivist e-learning environments. Within these e-learning environments, learners take on responsibility for their learning process by managing the learning activities and collaboration with others. The constructivist e-learning environments are capable of offering personalised content, track learning activities and offer dynamic feedback to the learners.

Immediate gathering of the learner's actions within a tracking process helps in the generation of constructive feedback. The theory of constructivism enables us to identify important features for the learning process, such as personalisation of content to the individual learner; tracking the learner's activities at each level of the learning process; and generating feedback.

The basis for measuring educational and personal learning requirements achievement is driven by learning goals [8]. The personal learning requirements, e.g., the personal learning style, prior knowledge, the learning needs, are captured in a user profile [9]. This information will be the input for selecting, sequencing and presenting the information content which meets the users' requirements. Figure 1 describes the conceptual model, containing five components: *Overview*, *Summary*, *Information Object*, *Practical Object*, and *Assessment Objects*.

The *Overview* contains general information about the module, such as the module code, level, aims/objectives, pre-requisites, co-requisites, learning outcomes, indicative content, assessment strategy, and credits. Metadata is used to describe the

objectives for the different objects within the Learning Object. The *Information Object* component represents a topic within the module. The practical instruction on this topic can be composed in a Practical Object which describes the topic applications. The Assessment Object contains questions that measure the learner's competence against the learning objectives. The assessment questions are designed to test for both application and theory understanding of the topic. The assessment questions assess one or more objectives within the topic/module. The information encapsulated in this object contributes to composing the feedback. The *Summary* contains a review of the module, which assists students in self-assessment and self-reflection through recommendations.



**Fig. 1.** Template for module package

The learning objectives for each Information Object are sub-objectives for the overall module objectives. Therefore attaining the objectives at Information Object level, reflects that the learner has attained the module learning objectives.

A well designed learning environment should be capable of facilitating learners at the different stages of learning and levels of content. The learners should be able to achieve their learning goals and receive effective feedback on how they can improve so as to attain all learning objectives. The tutors and instructional designers should be able to receive responsive feedback on the content effects to the students. The dynamic feedback acts as a support for learners to improve on their knowledge construction process, for tutors and instructional designers on how they can improve on their content instruction. A model that generates dynamic feedback at each level of the Learning Object content is developed to improve on the personalised learning process.

### 3 Feedback Process

Feedback may be described as a proactive process in which communication takes place in response to the learners' activities and outcomes. It is believed that feedback

has a significant impact on the learning process since it adds value that results in improving quality and success in knowledge construction. Gagne and Briggs [12] stress that there is need for evaluating the student’s understanding and offering feedback during evaluation within an effective learning. The feedback is important to the tutors because it reflects how best the student gained in the learning process and may also indicate what instruction content is inadequate.

Feedback can be generated for different purposes depending on a nature of assessment: formative and summative. The feedback for formative assessment puts emphasis on the student’s self-reflection and self-direction. The learner can improve their understanding by being continually assessed. The comments in the feedback can be generated from the specific learning objectives associated with the Information Objects. In contrast, the feedback for summative assessment assists the measure on the overall learning objectives at the Learning Object level.

During learning, personalised learning activities are continuously monitored and the data corrected used for feedback generation. The learner-oriented tracking model [10, 13] collects useful information about the learning process which uses it for generating personalised feedback. Personalised information like assessment results is used for generating personalised feedback for learner, tutor and instructional designer.

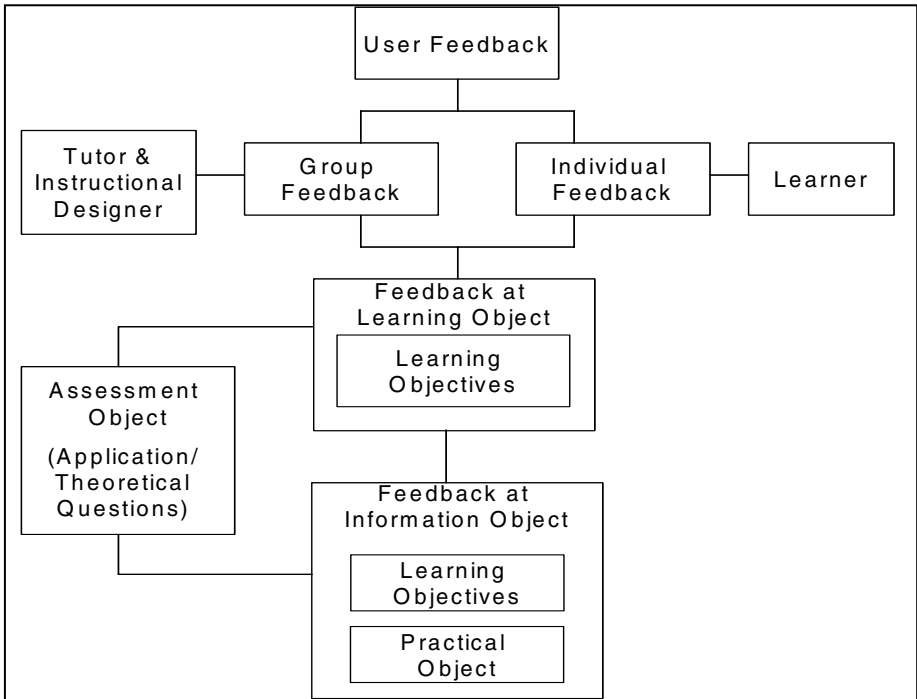


Fig. 2. A Dynamic Personalised Feedback Model

## 4 Personalised Feedback Model

The personalised feedback model shown in fig. 2 relies on the learning objectives specified in *Overview* of the Learning Object (LO). These learning objectives contain sub-objectives that are contained at the Information Object (IO). At both LO and IO an assessment object that contains a set of both application and theoretical questions is used to assess the achievement of the learning objectives. The feedback generated is based on the results from the assessment that reflect the attainment of the learning objectives. This feedback is generated based on the individual or group assessment results. The individual assessment results are used for generating feedback for the learner. The group assessment results are used for generating tutor and instructional designer feedback.

The model illustrates what feedback can be generated for learner, tutor and instructional designer. The assessment question type on which the model is applied is the commonly used multiple choice. The assessment question results are computed based on the set of application and theoretical questions. Once these results have been computed, a suitable feedback template is chosen, feedback determined and generated. The assessment results are computed at the LO and IO as follows:

Assessment results computed at LO: ( $Q_G$ )

$$Q_G = \sum_{i=1}^n (P(sa/SA) + T(sa/SA))/n \quad (1)$$

Assessment results computed at IO: ( $S_G$ )

$$S_G = \sum_{i=1}^n (P(fa/FA) + T(fa/FA))/n \quad (2)$$

### Where:

$n$  = Number of learners who participated in the attempting assessments.

$P(sa/SA)$  = Assessment result ratio of the attained application related questions to the total application related questions within the summative assessment at the LO level.

$T(sa/SA)$  = Assessment result ratio of the attained theoretical related questions to the total theoretical related questions within the summative assessment at the LO level.

$P(fa/FA)$  = Assessment result ratio of the attained application related questions to the total application related questions within the formative assessment at the IO level.

$T(fa/FA)$  = Assessment result ratio of the attained theoretical related questions to the total theoretical related questions within the formative assessment at the IO level.

## 5 Application of the Model in Feedback Generation

Applying the personalised feedback model to generate feedback is described in this section. A case study that describes an Information Technology module e-Business is used. This module teaches students to design web sites using the Dreamweaver application [14]. A section from the module content is considered for illustration and

explains how the personalised feedback can be generated at each level and in different forms.

The student has to learn how to design dynamic web pages using the Dreamweaver application. The module used here is Designing Dynamic web pages (Learning Object). The module contains several objectives including: using dreamweaver windows, dynamic functions and palettes, learning how to set up an ODBC connection, learning how to create a record set, creating a dynamic table, adding repeat region and navigation server behaviours, creating a record insertion web page, creating a master-detail web page, creating a search web page, creating a login web page, creating a delete web page, creating an update web page

A summative assessment is used to assess the achievement of the objectives in both application and theoretic knowledge of the module.

A topic (Information Object) within the module “Using dreamweaver windows, dynamic functions and palettes” is considered during the application. The topic contains the following objectives: being able find and use the different palettes, selecting what window view to use during design, the dynamic functions that may be used to design dynamic pages, how to save the dynamic pages without using the HTML extension.

An assessment containing a set of application and theoretical multiple choice questions is presented to the learner for assessing their knowledge construction. Figure 3 describes the sample questions that may be used for assessing the learner at different levels within the Learning Object.

### Assessment One

Q1. Which menu do you use to turn on and off all Dreamweaver's Palettes and inspectors?

- Insert Menu
- Modify Menu
- Window Menu
- View Menu

Q2. The asterisk (\*) sign at the end of the file name in Dreamweaver indicates ?

- Document name corrupted
- Document name error
- Documented is untitled
- Document is not saved

Q3. The Object Palette contains all these types of objects apart from?

- Common Objects
- Design Object
- Character Object
- Forms Object

Q4. Dreamweaver view window that allows viewing both design and code is called?

- Code View
- Code Design View
- Design and HTML View
- Code and Design View

**Fig. 3.** Description of an assessment containing multiple choice questions

If we consider the assessment in figure 3 as containing 30% application related questions (Q1, Q3, Q4, Q6) and 70% theoretical related questions (Q2, Q5, Q7, Q8, Q9, Q10). These rates reflect the achievement that can be obtained of the learning objectives. This achievement can then be used for generating feedback depending on level at which the assessment is taken. Examples of feedback that may be generated from the assessment results are shown below.

**Feedback Generated for Learner at the Learning Object Level.** Considering figure 2, the feedback that may be generated at the Learning Object level is based on the result from equation 1. When a summative assessment is taken by a learner, the results indicate that 55% of the applications questions set and 50% of the theoretical questions set were attempted right. Calculating for  $P(sa/SA)$  we obtain 16.5 and for  $T(sa/SA)$  we obtain 35. When equation 1 is evaluated where  $n = 1$  (learner), the overall assessment result is 51.5% total objectives achieved. The feedback that can be generated for the learner at the Learning Object level based on the summative assessment results includes: “You have successfully attained 51.5% of the learning objectives for this module. Both your application and theoretical understanding were relatively good. However for a better achievement of the learning objectives, you need to read carefully the content and probably do more practical work”.

**Feedback Generated from a Group of Learners.** Feedback generated for tutor and instructional designer is based on the group assessment achievement on the learning objectives. Considering figure 2 and assuming  $n$  learners have attempted the assessment, the achievement of the learning objective by the group is evaluated using equation 1. When a number of students ( $n$ ) attempt the summative assessment, they attain different learning objectives. However the overall attainment of the learning objectives by the students may reflect the understanding they have acquired during their knowledge construction. The feedback generated would give an insight to the tutors and instructional designers the instruction that is inadequate. A small group of student attained 16.5, 12, 10, 8 and 6.5 for the application related questions calculated from  $P(sa/SA)$ . The same group attained 35, 30, 22, 18 and 18 respectively for the theoretical related questions calculated from  $T(sa/SA)$ . Applying equation 1 to the results, where  $n$  is 5 students; the overall achievement of the learning objectives in the module by the students is 35.2%. This value reflects the average achievement attained by the group of students on the module objectives. The feedback that can be generated for the tutor and instructional designer includes: “On average the class attained 35.2% of the module learning objectives. This is a failure in attaining the minimum module objectives by the group. On average the group is poorer in application than theory. Therefore you need to improve the instruction for both theory and application content if a better performance is to be attained.”

**Feedback Generated for the Learner at the Information Object Level.** Feedback generated at the Information Object level for the learner as shown in figure 2 is based on the formative assessment. When the assessment is attempted, the learner attains 80% of the application related questions and 75% of the theoretical related questions. Therefore  $P(fa/FA)$  and  $T(fa/FA)$  evaluate to 52.5 and 24 respectively. On applying equation 2 the overall learning objective achievement where  $n$  (learner) = 1 is 76.5%.

The feedback that may be offered to the learner about this topic includes: “Congratulations you attained 76.5% of the learning objectives. Both your application and theoretical skills were good. You can proceed to the next topic.”

During the generation of feedback, the contents may vary depending on what was achieved from both application and theoretical related questions within the assessment. Once the achievement has been determined, a feedback template is selected and the feedback contents determined. The feedback is then generated for the learner to improve their knowledge construction and tutor/instructional designer to improve on the content instruction.

## 6 Discussion and Future Work

A dynamic personalised feedback model is designed measure the learning achievements. The model is capable of generating feedback of different forms at different levels during the learning process. Feedback generated for students is dynamically delivered to them at the different levels of the learning process. This motivates them to put more emphasis on the areas where improvements are required.

Generation of the feedback during the learning process is to be allocated to a feedback agent that will carry out this work on an independent basis. This agent will link up with another agent that will distribute the feedback to the different users. The feedback templates for the feedback tree will be designed. The feedback templates will be dynamically selected for feedback generation at different levels during the learning process. Related work on learner profiling and Learning Object repositories are underway. These will be used with the learner-oriented tracking model to offer an effective learning process. The dynamic personalised feedback model can be embedded into the learner-oriented tracking model to improve student’s support during the learning process.

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