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DECISION MAKING IN COURSE DESIGN

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ABSTRACT

Decision making is an important feature of design. Although engineering design refers to the design of products and technical systems, design activities occur in many other professions, including education. As education moves from teaching to learning, engineering faculty are becoming course designers who make many decisions when designing a course. Although many course design processes have been described, previous work has not considered course design as an interrelated set of decisions. To plan a course, a designer must make decisions. The course designer must select following elements: the purposes of the course, the content, its sequence, the instructional resources, and the instructional processes. These decisions occur at different "levels": some determine "small" parts of the course (such as the media for one activity), and some determine "large" parts of the course (such as the sequence of topics). This paper, an initial step towards decision-based instructional design, describes the decisions that need to be made to design a typical academic course, the different ways in which these decisions are logically related to each other, and the objectives relevant to these decisions. These descriptions, which focus on the logical relationship between the decisions, do not form a complete course design process. Designing better courses requires selecting better alternatives for the many decisions that must be made. The objectives used to guide these decisions are thus a critical part of course design. These objectives include meeting a specific need in a satisfactory way, using an established rule or heuristic, maximizing effectiveness, optimizing a metric that is correlated with effectiveness, reducing the costs and resources required to develop and offer the course, and maximizing cost-effectiveness. This paper presents a simple model that describes the relationships between the course design, the instructor's actions, the students' actions, the initial and recurring costs of a course, the course effectiveness, and the utility (value) of the course. Based on this model, one could formulate a comprehensive instructional design problem: select the course design that maximizes the expected utility (value). Although there may be other factors that should be included in this model and we may currently be far away from formulating and solving this comprehensive instructional design problem, it can serve as a goal to motivate future research. This paper presents a new perspective for understanding course design, and elaborating this view can increase our understanding of engineering education and help those who are designing engineering courses. Describing these steps as decisions is an important step towards helping instructors make better decisions, which can yield more effective course designs and enhance student learning. This paper adds to our knowledge of engineering education by identifying the types of decisions involved and the objectives that can be used to make those decisions.

INTRODUCTION

Decision making is an important feature of design. Although engineering design refers to the design of products and technical systems, design activities occur in many other professions, including education. As education moves from teaching to learning, university faculty are becoming course designers who make many decisions when designing a course [1-3]. This paper considers instructional design in general and course design in particular. (Instructional design also includes curriculum design, the design of industrial and military training, and other similar activities. Instructional design is also known by other terms, including "instruction systems design" and "learning systems design.")

Instructional design experts have described a variety of instructional design processes [3-7]. These processes identify the steps needed to design a course. The processes are based on philosophies of learning, empirical knowledge of how people learn, and the practical experience of those who design courses.

A typical instructional design process resembles the product development processes that are taught in engineering design courses: one first analyzes the needs to identify the appropriate learning objectives, then develops a solution that satisfies those needs, then tests and revises the solution, and finally implements it.

Engineering design (and other types of design) occurs via a series of decisions [8-12]. Each decision is a choice from a set of alternatives, and the decision-maker must consider multiple objectives and constraints. Some decisions may be done sequentially, while others occur concurrently, and different patterns of decision making can occur [13]. A design process includes the tasks needed to make these decisions. Because design processes and decision-making techniques vary widely [14], however, designers experience design work in multiple ways [15].

Like that work, this paper describes instructional design as a set of decisions. This initial step towards decision-based instructional design will describe the decisions that need to be made to design a typical academic course, the different ways in which these decisions are logically related to each other, and the objectives relevant to these decisions. These descriptions do not form a complete instructional design process. Instead, they form a new perspective for understanding instructional design, and the last part of this paper will propose ways in which elaborating this view can increase our understanding of engineering education and help those who are designing engineering courses.

INSTRUCTIONAL DESIGN PROCESSES

Learning is a complex process, and there are multiple theories that describe how learning takes place. Behavioral learning theories describe how external conditions influence learning. Cognitive theories describe the ways that persons process, store, and retrieve information. Constructivist theories describe the ways that learners construct knowledge as they explore the world. Instructional designers rely upon one or more of these theories to inform their work as they progress through an instructional design process.

Dick et al. [7] presented an instructional design process that has two major stages: (1) develop the instructional strategy, and (2) develop and select the instructional materials. The first stage consists of the following steps:

- choosing a delivery system,
- sequencing and grouping clusters of content (skills),
- describing learning components,
- specifying how students will be grouped,
- establishing lesson structures, and
- selecting media.

Gagné and Briggs [4] presented a fourteen-stage instructional design process. Six stages are relevant to course design:

- determining course structure and sequence,
- analysis of course objectives,
- definition of performance objectives,
- preparing lesson plans,
- developing and selecting materials and media, and
- assessing student performance.

Diamond [5] presented a process with two phases: (I) project selection and design, and (II) production, implementation, and evaluation. Both phases include a series of steps. Phase I includes project selection, planning the "ideal" sequence, and specifying an operational sequence. Phase II, for each unit, determines the objectives, selects instructional formats, evaluates and selects existing materials, produces and tests new materials, coordinates logistics for implementation, implements, evaluates, and reviews the course.

Fink [6] described three course design phases. In the first, Fink suggested selecting or developing "learning activities that reflect the principles of active learning." The second phase includes sequencing the major topics, selecting specific learning activities, combining them into instructional strategies, and creating a schedule. The third phase concerns the grading policy, writing the syllabus, and planning implementation.

The "Understanding by Design" process [3] works "backward": in the first stage, the instructor should identify the desired results; the second stage includes determining acceptable evidence; in the third stage, the instructor plans the learning experiences and instruction. The third stage requires answering the following question: "What learning activities and teaching promote understanding, knowledge, skill, student interest, and excellence?" The process emphasizes using a research-based repertoire of learning and teaching strategies.

Some models of instructional design present a series of steps, but the need to return to previous steps and iterate in a way that interrupts the linear progression has been acknowledged [4, 7, 16]. Morrison et al. [17] highlighted the iterative nature of the process by presenting the instructional design activities as "elements" in an oval shape. Willis [18] presented a reflective design process that was deliberately "recursive"; that is, the instructional designers create, test, and refine a course design and consider parts of the course design many times throughout this spiral process.

COURSE DESIGN DECISIONS

To plan a course, a designer must make decisions. Although Lattuca and Stark [16] do not present an instructional design process, they do highlight the following elements that the designer must select: the purposes, the content, its sequence, the instructional resources, and the instructional processes. The remainder of this section discusses the decisions that are part of the instructional design processes mentioned in the previous section. The steps of instructional analysis and selecting the course objectives are not included in this discussion, although they are important prerequisites to designing a course. Of course, every part of an instructional design process involves decisions of some type, but this section focuses on the decisions that determine the course design.

The decisions included occur at different "levels": some determine "small" parts of the course (such as the media for one activity), and some determine "large" parts of the course (such as the sequence of topics). In the figures discussed below, each box represents a decision (a choice among alternatives), and the arrows between boxes represent a logical precedence: the first decision produces information that is required for the second decision. To save space, the repetition of the same decision, made multiple times for different parts of a course, is minimized.

Figure 1 shows the decisions described by Gagné and Briggs [4]. The designer must select the topics in the course and must sequence these topics. For each topic, the designer must select lessons for that topic and must sequence these lessons. (Note that the topics must be selected, but not necessarily sequenced, before the lessons for a topic can be selected.) For each lesson, the designer must select components for that lesson and must sequence these components. (A "component" is a skill that a student needs to accomplish the lesson's objective.) For each component, the designer must select instructional events for that component and must sequence these events. For each instructional event, the designer must select a medium.

Figure 2 shows the decisions described by Dick et al. [7]. In Stage 1, the designer must sequence the content of the course and must cluster the content. For each cluster, the designer must plan learning components for that cluster. (The learning components include preinstructional activities, content presentation, learner participation, assessment, and follow-through activities.) For each learning component, the designer must choose student groupings and select media. (Note that these two decisions are not coupled.) After all of the learning components in all of the clusters are planned, the designer must assign the clusters to sessions and select a delivery system for the course. In Stage 2, for each session, the designer must design instructional materials.

Figure 3 shows the decisions described by Diamond [5]. In Phase I, the designer must select the major elements for the course and sequence those elements, select the major instructional approach, select the units to be included, and sequence the units. In Phase II, for each unit selected, the designer must select the structure (the instructional setting), the process (e.g., whether to use self-paced instruction), and the technology to be used.

It is important to emphasize that these descriptions of the design decisions are not instructional design processes. Instead, these descriptions focus on the logical relationship between the decisions required to design a course. As they are based on published descriptions of instructional design, these descriptions are not equivalent to each other because they do not have precisely the same scope (the same decisions).

OBJECTIVES

Designing a course requires making decisions about its elements [1, 16], and designing better courses requires selecting better alternatives for the many decisions that must be made. The objectives used to guide these decisions are thus a critical part of instructional design. In general, instructors agree on the most important criteria for selecting topics, and they include fundamental topics that are important for students to learn, for instance [1]. The criteria for selecting instructional strategies are more diverse.

In practice and in the literature, a common objective is, simply, to meet a specific need in a satisfactory way. (This is the "satisficing" decision-making rule described by Herbert Simon.) If one needs a way to present the steps of the product development process, any media that can perform that task satisfactorily can be selected. For example, if one needs to provide precise corrective feedback to students who are learning an intellectual skill, interactive media such as a human instructor, a peer tutor, computer-based instruction, and programmed instruction are all satisfactory alternatives [19].

In some cases, a satisfactory alternative can be constructed by using an established rule or heuristic. For example, when determining the sequence of content to be presented, one should start with the lower-level skills and then move up to higher-level skills once the prerequisite subordinate skills are achieved [7]. For a laboratory course in which students should learn to design and conduct experiments and analyze and interpret data (an ABET criterion), Felder and Brent [20] suggested including fewer but more open-ended experiments. For a course in which students should learn the skills of problem analysis and engineering design, active learning and active problem solving are the best approaches [21].

In general, instructional design should lead to an effective course that can "activate and support the learning of the individual student" [4]. Therefore, alternatives should be evaluated based on their effectiveness. For example, one should seek a sequence of topics that promotes effective learning. Some recommendations about effective instruction are general observations of good teaching practice: for example, students learn better when working in a team effort, and students learn more when they have multiple opportunities to practice and demonstrate skills [22]. More generally, in science and engineering courses, student-centered instructional strategies are more effective than traditional instructional strategies [23].

In some cases, instead of explicitly considering effectiveness, one can consider a surrogate objective that is correlated with effectiveness. (The correlation may be based on learning theory, education research, or instructor experience.) For example, when developing instructional materials, one should select the illustration that minimizes the student's cognitive load [17]. A surrogate can be quite specific. For example, when planning a lesson on using visual and mathematical representations in science and engineering courses, including more explicit introductions to the modeling conventions is more effective [24]. A more general surrogate is to have an "engaging" plan, one that is thought-provoking, fascinating, and energizing [3].

The costs and resources required to develop a course are also important. The design of a course must meet practical limitations about resources, including funding, classroom and laboratory space, computers and other information technology, and human resources for development and instruction [5]. Minimizing logistical problems and simplifying the implementation process are also relevant objectives because they are means to minimizing the resources required [5]. In particular, when selecting media, one can choose among the satisfactory alternatives by considering cost, availability, and convenience [19].

An even more sophisticated approach is to consider both the costs and (expected) effectiveness of the satisfactory alternatives and select the alternative that is "most cost-effective." Morrison et al. [17] defined "effectiveness" as "a level of satisfactory achievement for all learners" and, more precisely, as "the degree to which learners accomplish objectives for each unit or a total course." A long-term perspective on cost-effectiveness should consider not only the initial costs of producing and procuring materials but also the recurring costs associated with distributing materials to students and with the time spent by instructors to use the materials. For example, for presenting basic information or introducing or reviewing a topic, a well-organized lecture can be the most cost-effective alternative because it is relatively quick and easy to prepare or modify (for an instructor who is familiar with the material) and a very large number of students can attend the lecture and receive the content [17]. On the other hand, developing high-tech materials for a unit in a course that only a few students take will not be cost-effective because of the time and effort required.

DISCUSSION

The decision-based design framework [10] provided a perspective in which engineers could see how their design decisions were part of a larger (but more abstract) design problem that included many types of decisions, different types of uncertainties, and multiple objectives that all affected the profitability of the product (or system) that was being designed.

In a similar way, the model shown in Figure 4 may provide a new way to understand the relationships between the elements of course design. This simple model complements the sociocultural context and the design-evaluation-adjustment cycle described by Lattuca and Stark [16]. This model, which is a type of influence diagram, shows that the initial and recurring costs of a course are determined by the course design. The course design, along with the instructor's actions and the students' actions (which are uncertain), affect the course effectiveness. The different costs and the course effectiveness determine the utility (value) of the course. This value describes the desirability of the outcome from the designer's perspective and reflects the designer's preferences. An outcome that the designer prefers more will have a greater value.

Here, we can imagine a comprehensive instructional design problem: select the course design that maximizes the expected utility (value). Formulating this problem would require knowledge about how the elements of a course affect the initial and recurring costs (which is difficult but feasible to determine) and how the elements of a course affect its effectiveness. This latter type of knowledge is generally unknown by course designers, although some may know which alternatives are more effective than others. More discipline-based education research is needed (1) to determine a method for measuring effectiveness and (2) to measure the effectiveness of different instructional strategies. Finally, the designer's preferences related to initial costs, recurring costs, effectiveness, and risk must be studied to create a reasonable utility function.

Although there may be other factors that should be included in this model, and we may currently be far away from formulating and solving this comprehensive instructional design problem, it can serve as a goal to motivate future research.

SUMMARY AND CONCLUSIONS

Instructional design requires making decisions. Although descriptions of instructional design processes focus on the steps in the process, these steps lead to making specific types of decisions about the course design. Describing these steps *as decisions* is an important step towards helping instructors make better decisions, which can yield more effective course designs and enhance student learning. This paper adds to our knowledge of engineering education by identifying the types of decisions involved and the objectives that can be used to make those decisions.

In particular, course designers who become familiar with the relevant research on effectiveness will be able to consider the effectiveness of the available alternatives (especially for instructional strategies, classroom activities, and media) and use this information to make a more objective, evidence-based decision that balances the desire for effective courses with the need to avoid excessive costs.

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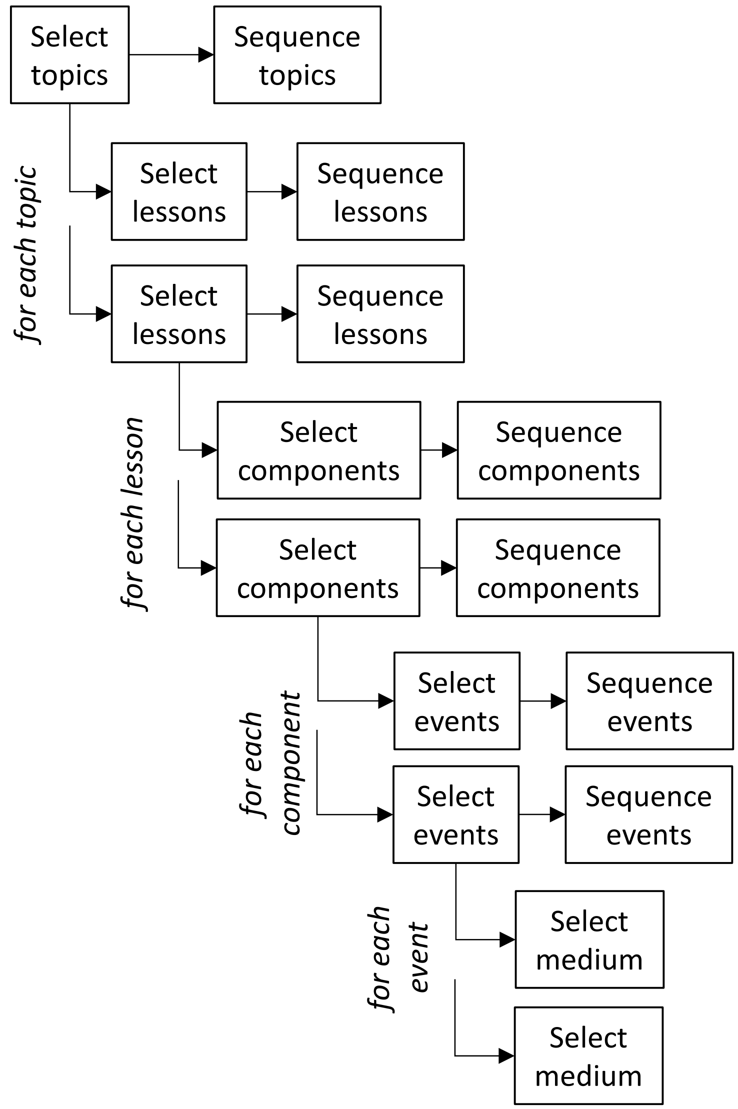

Figure 1. THE INSTRUCTIONAL DESIGN DECISIONS DESCRIBED BY GAGNÉ AND BRIGGS [4].

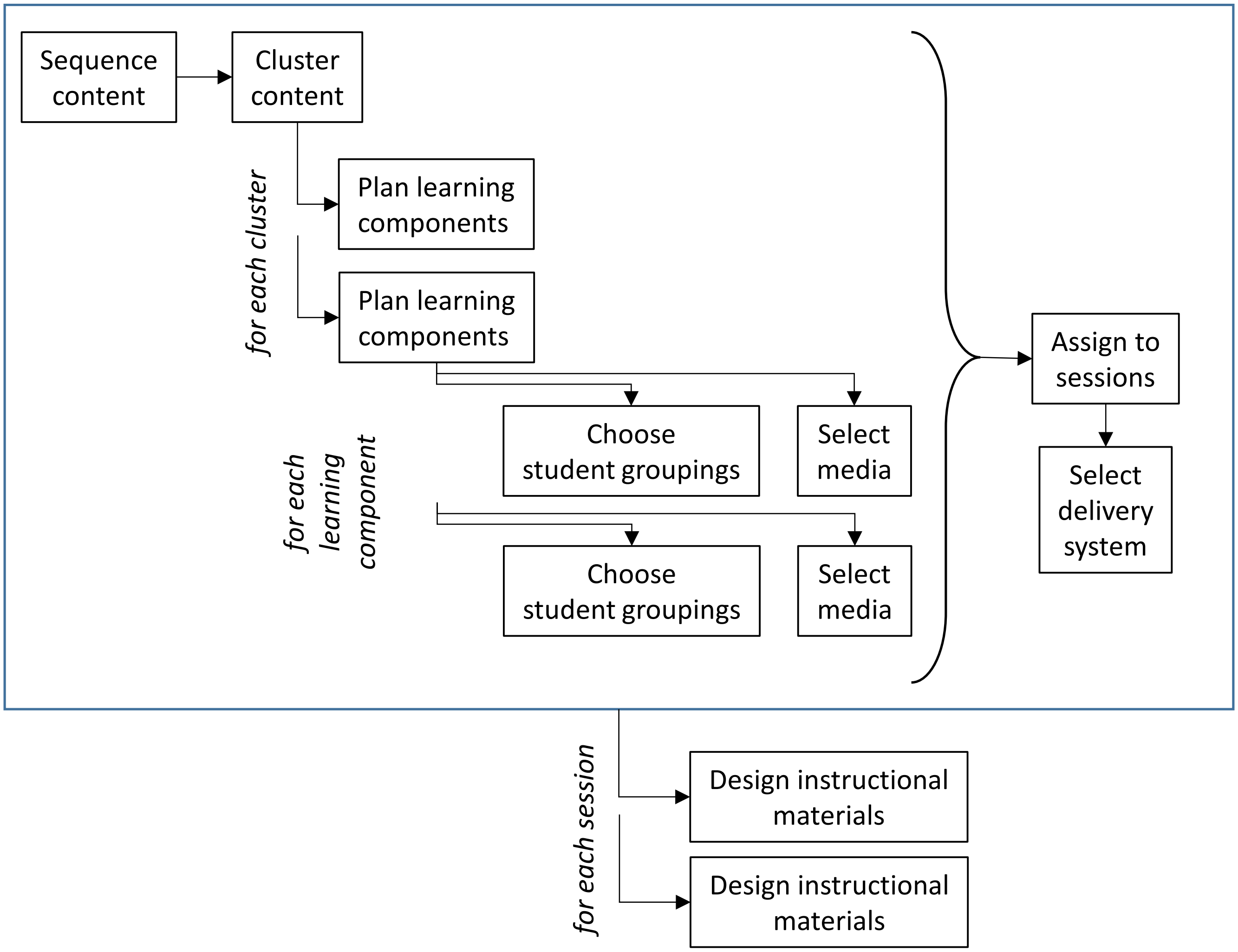

Figure 2. THE INSTRUCTIONAL DESIGN DECISIONS DESCRIBED BY DICK ET AL. [7].

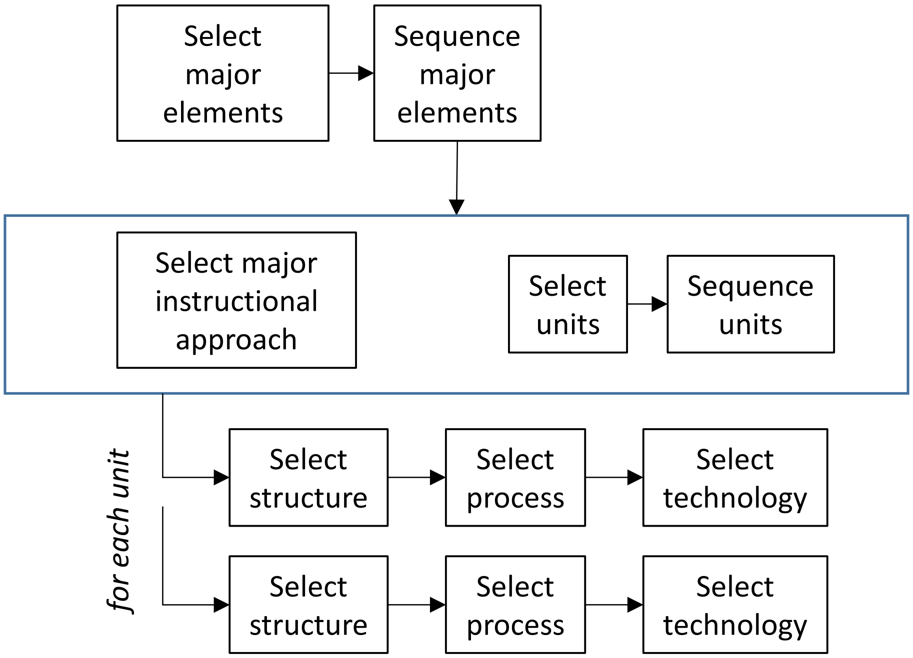

Figure 3. THE INSTRUCTIONAL DESIGN DECISIONS DESCRIBED BY DIAMOND [5].

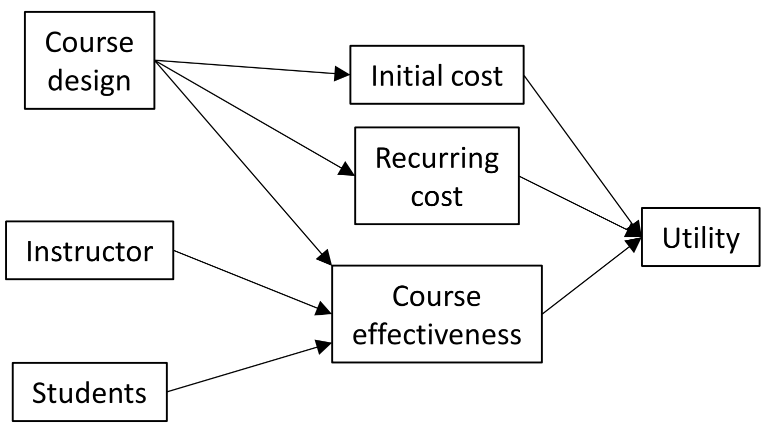

Figure 4. THE RELATIONSHIPS BETWEEN THE ELEMENTS OF COURSE DESIGN.