# Synthesis Fundamentals Seminar: *Testing the Instructional Project Development and Management (IPDM) Model*


by

Christian Fowler


Major paper submitted to the Faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

MASTER OF ARTS
in
EDUCATION

APPROVED:

Glen Holmes, chair

John Husser

John Burton

April 1996

Blacksburg, Virginia


Key Words: Gentry, Instructional Design, Musical Synthesizer, IPDM

# Abstract

SYNTHESIS FUNDAMENTALS SEMINAR:

TESTING THE INSTRUCTIONAL PROJECT DEVELOPMENT AND MANAGEMENT (IPDM) MODEL

by

Christian Fowler

Glen Holmes, Chair

Department of Teaching and Learning

(ABSTRACT)

This paper presents the development of an instructional unit that tested an instructional development model. The model was based on the Instructional Project Development and Management (IPDM) model designed by Castelle Gentry. A short student seminar was developed using the stages and techniques proposed by Gentry. The subject of the seminar was electronic music synthesizer programming. An evaluation of the seminar concludes that it is an efficient and complete model for developing instructional units.

## Acknowledgment

I wish to thank the Virginia Tech Department of Music for their overwhelming support. I would also like to thank my committee members, Glen Holmes, chair, John Husser, and John Burton. Thanks also to the Apple Macintosh which has empowered to achieve everything I dream. Thanks to my parents, and particularly my father for nudging me into graduate school. But most of all, thanks to Leslie Fowler, my wife-to-be come May 25, 1996, for her constant support and her beautiful smile. Yes, we have the same last name prior to our marriage!

# Table of Contents

## List of Figures

# 1.0 Introduction

Instructional design is a critical aspect to all fields of education. It is responsible for directing the flow of knowledge from the instructor to the student. The goal of this research was to test the effectiveness of a particular instructional design methodology. This was done through the implementation of a short seminar which was designed using an instructional model based on the *Instructional Project Development and Management (IPDM) Model* presented by Castelle Gentry (1994). This research was intended to fulfill the requirements for a graduate level project. As such, it is similar to a thesis, though more limited in scope. It is also intended to serve as a preliminary study and to orient the researcher with the field of educational research. The results and experiences of this research will ideally be used in future research. Such future experiments may include comparing instructional design models and techniques.

Smith and Ragan (1993) define instructional design as "the process of translating principles of learning and instruction into plans for instructional material and activities" (p. 2). Instructional design can be thought of as a system containing many interacting components. These components must be developed and implemented to complete an instructional course. An analysis by Gustafson and Tillman (1991) of numerous models also revealed that all models have components which involve: "analyzing what was to be learned, who was to learn, describing in detail how the learning was to occur, conducting a formative evaluation, and finally conducting a summative evaluation of the effectiveness of instruction" (p. 9). These components can be implemented in many different ways, and researchers have developed many methodologies to implement them. Such a methodology is known as an instructional design model.

While most models consist of several components, or steps, all of the components are heavily interrelated. A change in one component often results in a change in another (Gentry, 1994). Another similarity is that hardly any design follows a rigid linear sequence. While a model may have a suggested sequence of steps, most designers must backtrack or skip steps. Some steps must be completed before others due to time constraints, or perhaps earlier steps might need revision due to developments in later steps (Gustafson and Tillman, 1991). While the individual techniques used may vary, these properties are included in nearly all instructional design models.

## 1.1 The IPDM Model

The Instructional Project Development and Management (IPDM) model presented by Gentry (1994) is allows designers to fully implement a complete instructional unit. Pictured in Figure 1, the 14 circles in the IPDM model represent the necessary components. To complete each component, the use of a particular method is used. These varying methods are called techniques. Typically, several different techniques exist for each component. It is left to the designer to select the technique that best suits the project.

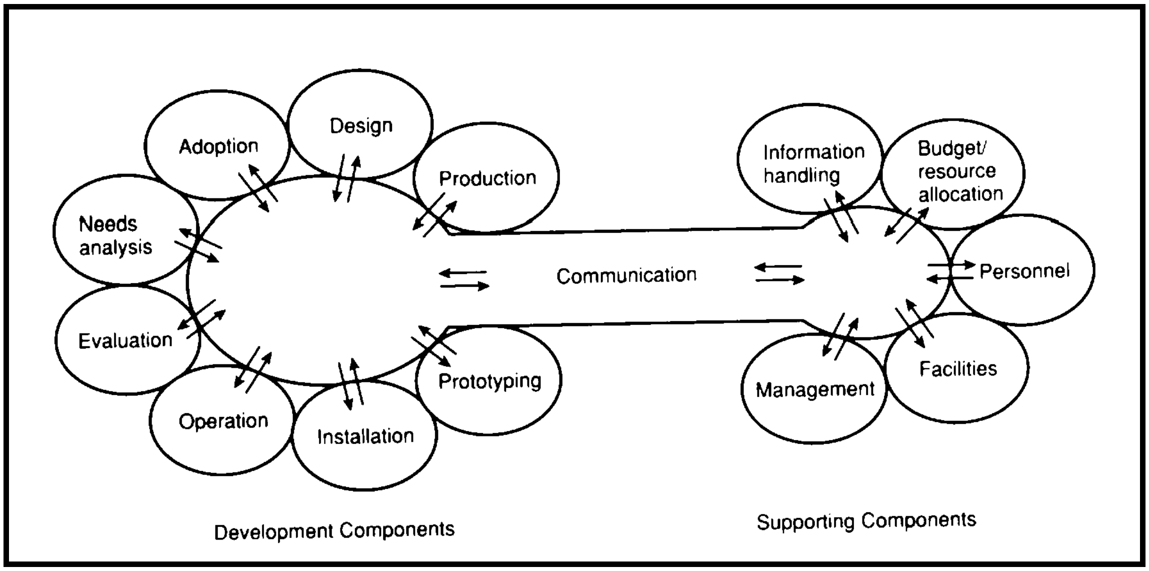



**Figure 1** - Instructional Project Development and Management (IPDM) Model

The components are divided into two groups. One is for developing and the other for supporting the project. The development group has to do with explicitly implementing instructional material. The supporting group has to due with the management of implementing the material. There is a line of communication between the two groups. This communication is important to the model since support for the project often affects development. Development is also likely to have an impact on the support components. Each group in the IPDM intentionally has a circular shape. This is to emphasize that the model is not linear. The starting place is usually the Needs Analysis phase, and the designer continues to work clockwise around the circle. However since most components are interrelated, it is quite normal to skip from component to component as the design evolves.

The arrows between the components represent how each component shares information with one another by sending and receiving information. Many models do not indicate how one component affects another. By illustrating arrows in and out of each module, this interrelationship is emphasized.

### 1.2 The Revised IPDM Model

Due to the level of this project, several components of the IPDM model were excluded and left to further research. A new revised instructional design model was developed by the researcher. It was closely modeled after the IPDM model. It contains all of the same components in the development group of the original model. The revised version of the IPDM model is pictured in Figure 2, and was the model used in this research.

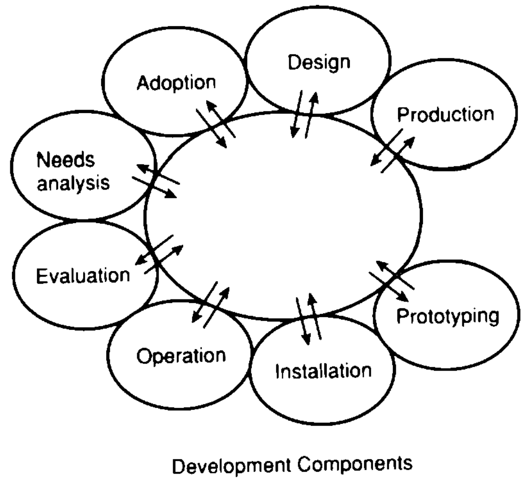



**Figure 2** - Revised version of IPDM Model

It was hypothesized that the instructional unit designed with IPDM model would be effective in instructing students. However, it was not the focus of this research to concentrate on the degree of effectiveness. This study was intended to be the beginning of a series of studies. Additional studies will be more advanced and complete a thorough evaluation of aspects that contribute to the reliability of the results.

## 2.0 Methodology

The revised IPDM model was used to implement a short seminar. The subject of the seminar was the fundamentals of electronic music synthesizer programming and the instructional unit was formally called the "Synthesis Fundamentals Seminar". Its intent was to give students a brief but thorough introduction on the complexities involved in programming an electronic musical synthesizer. The seminar was taught in conjunction with a semester course offered by the Virginia Tech Department of Music. The course number was MUS 2054 and was titled "Intermediate Midi Applications".

### 2.1 Participants

The target population for this study was college-level students, with some degree of musical experience. The students were in intact groups, thus already arranging themselves in a subgroup of the target population. Initially only one group was used for the treatment. However, future studies could include many groups, including a control and random selection, thus giving the research a true experimental design.

There was a trade-off in selection of the participants. Due to the resources for this research, students could have either been attained from an intact group or by gathering volunteers. Volunteers may tend to be less reliable. By selecting students from an actual class, it was hoped that they would take the seminar more seriously. There was also less chance of experimental mortality since the students were required to be present.

There were drawbacks to using an intact group. Student attitudes were of significant concern to the study. The members of the class were taking it as a course elective.  Therefore it was assumed that the some students might more motivated to learn the material than if they had been required to take the class. The *Hawthorne effect* (Ary, Jacobs, & Razavieh, 1996) also threatened validity. This occurs when students in a class show increased performance when they are aware they are participating in a study. Since the results of the evaluation test were counted towards each students final grade, it is hoped this effect was minimized.

### 2.2 Instruments, Measurements and Analysis

It was estimated that the instructional unit designed with IPDM model would be effective in instructing students. To show this relationship, a measure of students achievement was taken. A short preliminary examination was given to gauge student knowledge. A final examination was given to gauge student performance.

Developing pre and posttests is part of the instructional design process and much attention was given to their development. These two tests were unique, however they were based on the same instructional material. The pretest was brief but reflected the primary instructional objectives. The items were developed using several techniques proposed by Gentry (1994).

The general scores were evaluated. The validity and reliability were also determined. To measure the reliability of the instrument, the Cronbach Alpha formula was used, which is pictured in Figure 3.

**Formula:**

$$\alpha = \frac{K}{K-1}\left[1 - \frac{\sum \sigma_i^2}{\sum \sigma_i^2 + 2\left(\sum \sigma_{ij}\right)}\right]$$

**Where:**

$k$ = # of items

$\sum \sigma_i^2$ = sum of item variances

$2\left(\sum \sigma_{ij}\right)$ = 2 times the sum of the covariances OR (total variance of the Test - sum of the item variances)

**Figure 3 - Cronbach Alpha Formula**

The administration of a pretest was of concern. In previous studies, higher posttest scores have been reported due to pretests. It has been hypothesized that the pretest serves as a practice for the students and students are prompted by the test questions to be aware for key concepts and ideas (Ary, Jacobs, & Razavieh, 1996). Since the pretest for this research was short, it was hoped that this effect was be minimized.

# 3.0 Design Implementation

## 3.1 Needs Analysis

The starting component of the IPDM model is the Needs Analysis phase. A needs analysis, which is synonymous with needs assessment, is defined by Gentry (1994) as "a process by which a system's needs and goals are identified, and priorities among them are decided." He also defines a need as "any significant discrepancy between the desired outcome and the observed outcome." Due to the nature of this project, a formal needs analysis is not required. However, a needs analysis is critical to instructional design. Therefore, a simplified needs analysis had to be conducted in order to build a firm foundation for this instructional unit.

The initial impetus for this research was from a personal interest by the researcher and an anticipated need from the Virginia Tech Department of Music. The music department was currently developing an advanced program of study in music technology. Discussions with the department revealed that an area of instruction lacking in the curriculum was in the area of electronic sound design. The program is only offered to college-level students, thus narrowing the target population. After discussing the goals of the music technology program with the head of the department, a consensus was reached that instruction was needed to teach students the fundamental elements involved in electronic music synthesizer programming.

A more formal needs assessment was conducted to reveal the exact needs required to implement instruction in music synthesizer programming. This was done through an abbreviated use of the Delphi technique. This technique attempts to arrive at a consensus by having experts answer a series of questions. According to Gentry (1994), this process begins with the assumption that there is no clear goal for the instruction. Experts in the field that is being researched are asked an initial question. The experts' responses are compiled and used to form a general consensus. Once a general consensus is formed, another question is put before the experts. Their responses are compiled again, and another consensus is formed. This is repeated until a goal is arrived upon that satisfactory to the researcher.

In this research, the experts were asked a series of questions simultaneously. Their responses were then compiled and reviewed. The experts included the head of the music department at Virginia Tech, as well as several instructors in music technology and instructional design. The questions, and some responses, can be found in Appendix A.1.

Early discussions with the head of the music department led to the development of the following questions.

1. What components of synthesizer programming do you consider necessary for successful teaching of the basics of synthesizer programming?
2. What areas would you consider irrelevant to a discussion on fundamental synthesizers?
3. To whom do you consider this instruction should be directed? (i.e. Academic level of students)
4. What level of knowledge would you consider an individual to have in the area of Music? Computers? and Synthesizer Manipulation?

5. What tasks would you consider the student to be able to accomplish at the completion of the seminar?

The questions cover the overall goals of the seminar including material to be covered and student performance. The actual questionnaire appears in Appendix A-1. The experts for this study were John Husser, Department of Music Head, Jim Sochinski, professor in music technology, and Michael Dunston, instructor in music technology. The responses were collected, and compiled. They appear in Appendix A-2.

### 3.2 Adoption

This component is the process of securing acceptance for the instruction by those individuals for whom the course is being designed. In this case, there were two decision makers. They were the head of the music department, John Husser, and the instructor of MUS 2054, James Sochinski. They both acknowledged an existing need for instruction on programming electronic music synthesizers and encouraged development of instruction to fill that need. Their approval was granted after discussing the intended design of the project.

### 3.3 Design

The Design component consists of specifying objectives, strategies, techniques, and the method of delivery used to meet the goals. It was the most extensive phase of the IPDM model. Gentry outlines an 11 step sequence to follow to efficiently create an effective instructional design. This process begins with the results of the Needs Analysis.

1. The characteristics of the target audience were the first design parameters to consider. The acquired data from the Needs Analysis phase defined several of these characteristics.
    - Students would be low- to intermediate-level college students
    - Students would have an advanced knowledge of music, however, they would not necessarily have any background in music synthesizers

2. The next step was to define overall course objectives. This was done by using the ABCD method of writing objectives. This method forces the designer to focus on the goals by clearly stating several important instructional parameters, such as a general goal, audience, conditions of instruction, behavior on which to focus instruction, and the desired proficiency of students demonstrating that behavior. The steps of the below follow the outline as specified by Gentry.

1. **General Goal -** To understand the basic principles involved in synthesized sound generation.

2. **Audience -** College-level Students

3. **Behavioral Focus -** To identify the sound-generation components of a synthesizer and define their function

4. **Teaching Conditions -** Traditional classroom based instruction

5. **Degree of Proficiency -** To be able to identify the sound-generation components of a synthesizer, and define their function, within a 25 minute test period

6. **Instructional Objective-** College-level students will be able to identify the sound-generation components of a synthesizer and define their function within a 25 minute period.

3. Once the objectives had been stated, the type of learning they hoped to accomplish were specified. Through the use of Bloom's Taxonomy, the objectives were categorized as being in the cognitive-domain. Within that domain the objectives were categorized as Knowledge-Level. Knowledge-Level objectives require the learner to recall or recognize certain facts. In the SFS, the desired facts to be recalled were the names and functions of the sound-generation components of a synthesizer.

4. The performance objectives now required approval from the individuals overseeing the instruction. These individuals included Jim Sochinski, instructor of MUS 2054, and Glen Holmes, advisor to the researcher. Each person was briefed on the intended objectives and they granted their approval.

5. The instructional objectives then had to be sequenced so that the instruction could be delivered in a logical order. Often some objectives will precede others. An Objective Tree was used to prioritize the objectives. The tree begins with the ultimate goal of the instruction, followed by subsequent goals that are necessary to ensure completion of the overall objective. The objectives need to be completed first from the bottom-left of the tree, moving to the right, and up for each level, until the topmost objective is reached.

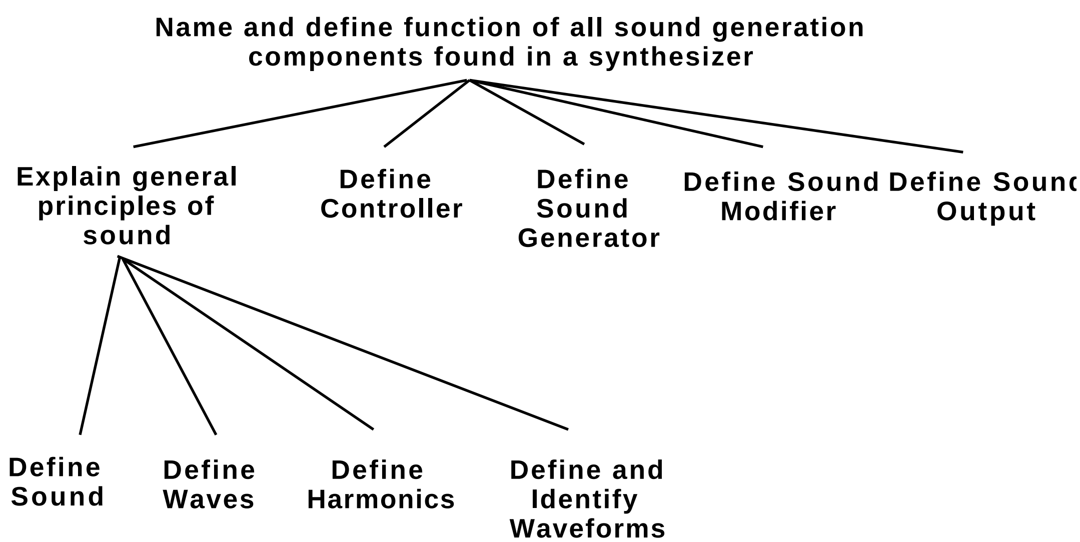



**Figure 4** - Objective Tree

6. The next step toward achieving a successful design is developing criterion test items. Test questions were developed for each of the instructional objectives in the Objective Tree in Figure 4. Several short-answer test items were constructed.

The short-answer questions were chosen since they have an advantage over multiple-choice or matching questions. They do not permit the student to guess the answer. While multiple-choice can be shown to be an effective tool for measuring student performance (Gentry, 1994), the lack of experience of the researcher in designing test questions, as well as the small size of the testing group, prompted short answer questions.

The development of the short answer questions involves a three step process. First, a question is written that is direct, matches learning appropriate learning outcomes, and has only a single brief answer. Each question below is labeled with a "Q". Next, the appropriate answer is written. Below, it labeled "A". Finally the question is written as an incomplete statement with a blank line to indicate where the answer should go. The incomplete statements are labeled "IS".

Q: What is sound?

A: Sound is the repeated compression and decompression of particles.

IS: Sound is _________________ .

Q: What two things must be present for sound to occur.

A: A vibrating body and a median to travel through.

IS: A _____________ and ______________ must occur for sound to occur.

Q: What waveform has no harmonics?

A: Sine wave

IS: A _____ _____ has no harmonics.

Q: Name 3 primary components included in most synthesizers.

A: Oscillator, Envelope, Control Source

IS: ________, _________, and _________ are three sound-generation components found in nearly all synthesizers.

Q: Name 3 three waveforms that are well-suited for synthesis?

A: Sawtooth, Square, Triangle.

IS: ___________ , ___________ , and ___________ are three waveforms well suited for synthesis.

Two addition questions were developed that required more involved answers than short answer.

Q: Name the four primary components of the Synthesizer Assembly Line, list their function, and give and examples of each.

A:Control Source - Provide information to synthesizer engine - Keyboard, Synthesizer Guitar, Elec. Wind, MIDI

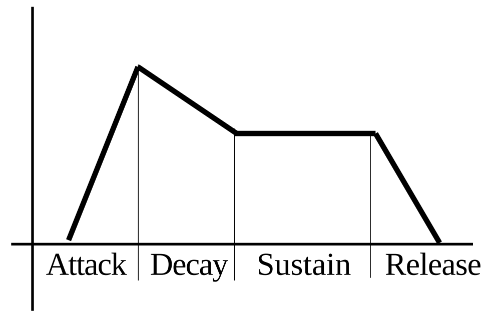
Sound Generator - Produce initial waveform - VCO, Digital Sample, Mathematical Equation

Sound Modifier - Sculpt initial waveform so it is more musical - Filter, Amplitude Envelope, Modulator

Sound Output - Amplify signal and route signal to proper output - Amplifier

Q: Draw a picture of an ADSR envelope and label its components.

A:




7. Once the objectives were defined, a task analysis was needed. The task analysis provides a complete evaluation of all the tasks involved in meeting the instructional objectives. There is considerable debate as to the extent and when a task analysis should be performed. In Gentry's methodology, there is not a significant amount of emphasis placed on task analysis. Therefore, the technique used in this research is less extensive than in many other instructional design models.

   The method proposed by Gentry involves 5 steps. First, all of the objectives and the tasks necessary to obtain them are stated. Many of these tasks had already been defined in the Objective Tree that was prepared when defining the instructional sequence for the SFS. The Objective Tree also had placed them in the logical sequence, which is the next step in the task analysis. Next, the tasks and the order of instruction were reviewed with Jim Sochinski, the instructor for MUS 2054 and expert in music synthesis. Finally, a learning strategy was selected for each task. Below are the tasks in sequential order, and their related learning strategy.

I. Know the physical properties relating to sound
  A. Define Sound - Verbal Chain Learning
  B. Define Waves - Verbal Chain Learning
  C. Define Harmonics - Verbal Chain Learning
  E. Define and Identify Waveforms - Verbal Chain Learning
II. Define all sound-generation components found in a synthesizer
  A. Define Control Source - Concept Learning
  B. Define Sound Generator - Concept Learning
  C. Define Sound Processor - Concept Learning
  D. Define Output - Concept Learning

As can be seen, all the first set of objectives require a verbal chain learning strategy. Common tasks suitable for this strategy are ones that require the student to list or define something. Common activities for this type of learning are to give an overview of the material, memorize the list, then practice the task. The drawbacks of verbal chaining are that the material is easily forgotten and there is little transfer to the job.

To account for those drawbacks, the second set of tasks uses concept learning. Concept learning is used when it is intended for a student to classify or distinguish something. This method uses examples, identification of distinctive attributes, group presentation, and rehearsal as the learning strategies. Results from concept learning include resistance to forgetting, easy job transferal, and the partial learning of the verbal chain associated with the group of concepts.

8. Selecting an instructional strategy is next and "one of the most crucial tasks for an instructional developer" (Gentry, 1994). To select the appropriate strategy for each objective, Gagne's Behavioral Hierarchy was used. It is a method to select the appropriate instructional strategy by determining the type of learning necessary to achieve the objective, and then establish the essential conditions under which the learning will occur. Finally, a list of possible strategies are evaluated and the ones that will most efficiently achieve the objective are chosen.

   By following the methods as presented in Gentry (1994), the following table was constructed using Gagne's Behavioral Hierarchy.

| **Objectives** | **Learning Type** | **Essential Conditions** | **Strategies** |
|---|---|---|---|
| define sound and its physical properties | Verbal Association | verbal s-r links<br>kinesthetic stimuli<br>response confirmation | Lecture<br>Discussion |
| define and distinguish between the sound-generation components of a synthesizer | Concept Learning | verbal chains already learned<br>novel stimulus for distinguishing<br>novel stimulus reinforcement | Lecture<br>Discussion<br>Practice |

9. The next step is selecting the instructional media. The media is the method in which the desired information is communicated. It had

been decided through the music department that the Synthesis Fundamentals Seminar was to be in lecture form. This is because the seminar was to be administered through an existing class, MUS 2054.

Through the use of the Merill and Goodman Strategy and Media Selection Technique, the different types of media involved in each component were decided. This technique, as presented by Gentry (1994), was a condensed version of the original. The method is to first determine to which domains the objectives belong - cognitive, psychomotor, or affective. Then a series of tables indicates the appropriate strategies for each of the objectives. This is known as a strategy prescription and contains strategies for presentation, practice, and evaluation. Finally, the proper media to be used with the strategies is determined through a final chart. Below are the results from this research.

**Objective -**

**Audience -** College-level Students

**Behavioral Focus -** To identify the sound-generation components of a synthesizer and define their function

**Conditions -** Students will be given a written examination

**Instructional Objective-** College-level students will be able to identify the sound-generation components of a synthesizer and define their function within a 25 minute period.

**Domain -** Cognitive

**Appropriate Strategy -** Naming

**Strategy Prescription -**

***Presentation***

Explain to students the different components involved in a synthesizer and how they interact. First explain basic acoustic properties, second display an image of the Synthesizer Assembly Line (SAL), third explain how each component operates, affects the overall output and how it is related to other components. The concepts will be demonstrated on an actual synthesizer.

*Media* - Presentation media will include objects, audio media, and written words and symbols. The objects will include the SE-1 synthesizer and the visual representation of the SAL. Audio media will be the aural output of the synthesizer, and written words will be overhead notes explaining the function of each component in the SAL.

***Practice***

There will be in class review of the SAL model. Students will be shown an empty model, and asked to identify each component, and state its function. On their own, students will be allowed to manipulate the SE-1 synthesizer to experience first hand the action of the synthesizer components.

*Media* - Practice media will be objects including the image of an empty SAL model during instruction time, and the SE-1 synthesizer during individual practice. Also, student will have written copies of the notes to review.

***Evaluation***

Students will be presented with a written examination. This will include an empty SAL model that they will be asked to identify the components, and state their function.

*Media* - Written words will be used to ask students to define the function of each component in the SAL. An empty written model of the SAS will be used for student to identify.

10. At this point, cost-effectiveness comparisons were made. This compares the possible methods of delivering and evaluating

instruction, how efficiently those methods accomplish their goals, and the resources available to implement those methods. In the SFS, some components, such as student evaluation using an actual synthesizer, had to be eliminated due to time and resource constraints. The resulting design is presented in steps 1 - 9.

11. Finally, the design specifications were formalized. This included documentation of all the previous design steps. This final step provides a documented plan for all of the developers and artisans who will work on the implementation of the design. It will be the basis for all development and therefore need to be concise and clear.

At this point the many phases of design had been completed. The actual instructional materials were ready to be developed.

### 3.4 Production

Production is the construction of the materials as specified in the design. Production went hand in hand with the Design component. As objectives were established, the corresponding course material was developed.

Since the researcher was also the lead developer, a formal breakdown of all duties was not necessary. He was responsible for all development of materials. As specified in the media selection part of the Design phase, the primary production components included developing a computer-based notes presentation, obtaining computer programs to help illustrate concepts, and developing synthesizer settings that demonstrated the topics discussed. The program used for notes presentation was Microsoft Powerpoint. An additional program was Harmonics for the Macintosh. A Studio Electronics SE-1 synthesizer was used for its very graphical display of settings and parameters.

The production cycle clearly demonstrated why instructional design is a non-linear process as it revealed some discrepancies in the objectives. For example, the objectives would jump from one concept to the next, without specifying an essential intermediate step. One case occurred when the objectives were written for waveforms, no objective was mentioned for the explanation of harmonics. Harmonics are an absolutely essential component to understanding waveforms, and thus understanding the many components of the synthesizer including the filter and oscillator. When this discrepancy was revealed, the objectives had to be modified to include this component.

Development of the computer-based notes echoed the strategies as outlined in the design phase. The task analysis revealed that presentation of sound characteristics should be presented with a verbal-chain learning strategy. For each task related to defining sound and its physical properties, a set of slides was developed. The slides defined each topic for student memorization. Review of the material at the beginning of each lecture was intended to provide ample practice.

To present the material relating to naming and defining the function of the major sound-generation components, concept learning was used. Since the concept learning intends for the learner to distinguish between components, a diagram was developed. It listed the primary sound-generation components of a synthesizer. First a diagram was developed that showed all of the components and how they related. This diagram was called the Synthesizer Assembly Line, and appears in Figure 5. Next, a series of slides were developed that defined the function of each component and named several real-world examples of each. The complete set of slides used in the presentation appear in Appendix C-1.

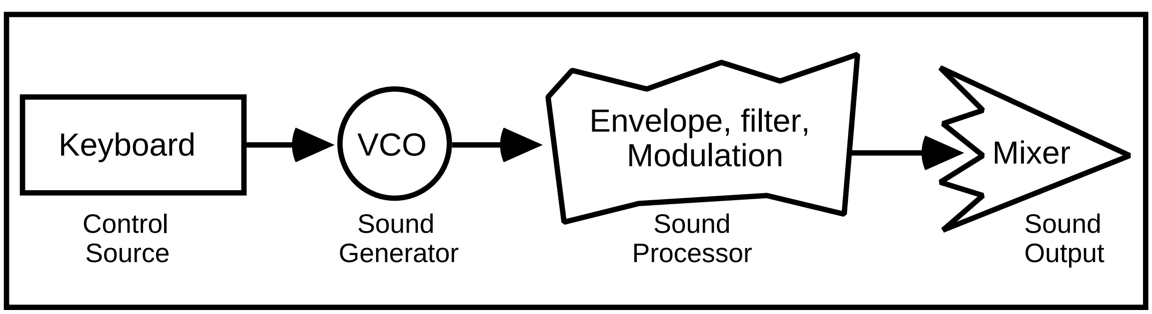



**Figure 5**- Synthesizer Assembly Line

Had this project been more involved, more elaborate techniques would be required to better manage the development of material. Gentry proposes the use of the *Program Evaluation and Review Technique (PERT)*. Formally, PERT is a "systematic programming, timing, and costing technique for measuring, monitoring, and controlling the development of a project" (Gentry, 1994, p. 124). Usually a graph is drawn out that contains the sequence of events and activities of the project. The graph is then used to compute time requirements, cost estimates, and break down the work load for developers. PERT is recommended for projects that last longer than one month and has 20 or more activities.

### 3.5 Prototyping

Prototyping includes assembling the necessary materials, tests, and other procedures just prior to the implementation of the instructional unit. Usually a small subset of the general audience is selected and administered the instructional material. The instruction is then evaluated for its efficiency at meeting the instructional objectives.

Synthesizer Fundamentals Seminar prototyping was implemented through administration of the materials to another related class in the music department. The class was MUS 2984 Music Technology. Since MUS 2984 is similar in subject to MUS 2054, it was an excellent resource to use for prototyping. None of the students in 2984 that participated in the prototype had much experience with synthesizers.

A prototype should undergo two types of evaluation- a formative and a summative evaluation. Formative evaluation is designed to detect problems in the instructional design during development. Summative evaluation attempts to provide evidence that an instructional unit teaches what it intends to teach.

The formative evaluation involved a one-on-one evaluation with both students and experts. Concluding each lecture, individual students were interviewed. Students were asked questions to see if they understood the concepts that were covered in the lecture. Additionally, student questions during and after class were noted. Concluding the lecture, John Husser, the head of the Music Department, and Michael Dunston, instructor of MUS 2984, were interviewed for any problems or discrepancies they perceived. Their experience with music technology and instruction assisted refining the instructional materials.

Ideally a written evaluation can be administered to students, to insure that the instruction is teaching what it is intended to be taught. Unfortunately, a written summative evaluation could not be administered during the prototyping phase of this project. Time constraints for MUS 2984 did not permit this.

Therefore, the summative evaluation was conducted through interviews with expert instructors who attended the lecture. An interview after each lesson provided feedback on the effectiveness of the lecture. John Husser and Michael Dunston were the two instructors who attended the prototype lectures. This information was not considered as reliable as a written evaluation, however it was used as an indicator to insure that basic concepts were being conveyed properly.

Some of the problems that were discovered through the formative and summative evaluations are presented below.

Concept explanation - Motion of waves, not graphic enough

Concept Explanation - It was not explained which synthesis method was being demonstrated for certain concepts. Therefore, it was necessary to explain that the subtractive synthesis model was being used.

Sequencing of material - When discussing sound modifiers, it was found that individuals preferred that envelopes, a tool used to control envelopes, be explained first

At the conclusion of the prototyping phase, the necessary adjustments were made to the design and instructional materials. The information obtained from the prototype was very valuable. It not only provided important feedback, but also gave the researcher experience presenting the instructional unit.

### 3.6 Installation

The installation phase confirms that all resources and approvals have been acquired to make sure the instructional unit will operate smoothly. This involves many of the same steps as the adoption phase. Important steps are getting final approval from all decision makers, ensuring support and resource facilities, and selecting and training teachers.

By the time the Synthesis Fundamentals Seminar was ready to be installed, approval from all decision makers had been acquired. All instructional and evaluation materials had been developed. It was necessary to prepare the classroom with the required equipment. The equipment, as specified in the Production phase, included an SE-1 synthesizer, a sound system, a computer, and software applications. The researcher was the sole instructor, therefore selection and training was not necessary. At this point the instructional unit was ready for operation.

### 3.7 Operation

The ongoing operation of an instructional unit is a maintenance and updating process. The unit and its components can tend to degenerate over time. During the operation, it is important to prevent problems from occurring, as well as quickly remedying any that have already occurred. Few problems occurred during the SFS due to the small number of individuals involved and the short operation time.

Operation occurred from March 25 through April 3. Concluding each instructional session, there was a review with Jim Sochinski, the instructor for MUS 2054. A problem that was brought up was that some slides were too small for the room in which they were presented. He also suggested using a special application that would allow switching between presentation notes and demonstration applications easily. These issues were quickly resolved.

### 3.8 Evaluation

Evaluation was conducted on April 3, 1996. This was done through a written examination as developed in the design phase. The test scores were reviewed, as well as several test statistics. The test was also assessed in two important areas: reliability and validity. A copy of the test appears in Appendix B-2. The results of the evaluation are pictured in Figure 7. These results were compared to the results of a pre-test which is pictured in Figure 6.

The mean of the final evaluation test scores was 92.95, with a standard deviation of 13.44. The high mean score led to the conclusion that the students had made a significant achievement. The low standard deviation score led to high reliability as calculated below.

A pre-test was administered on the first day of instruction. It was a short test designed to assess students knowledge level. A copy of it is pictured in Appendix B-1. The average score on the pre-test was very low, only 12.2%. Questions 1, 2, and 4 were scored for performance. While question 3 was subjective and used for needs purposes, questions 1 and 2 from the pre-test were identical to the questions on the post-test. On the pre-test, only two students got question 1 completely or partially correct. Two students got Question 2 completely correct, and eight got partial credit. The averages for these questions were incredibly low: 0.4 / 5 for Question 1, and 1.1 / 5 for Question 2. However, on the post-test the averages for questions 1 and 2 were 4.9 / 5.

Question 4 on the pre-test was the same as the first row in Question 7 on the post-test. In the pre-test, students were only asked to list three of the four primary components in a synthesizer, while students where required to name all four in the post-test. The results from question 4 are shown in figure 6. 4-A, 4-B, and 4-C indicate the three answers. Scores on the pre-test were also extremely poor, averaging 11.2% for question 4. However on the post-test, students scored an average of 85.5%, naming all four of the components.

| QUESTION | TOTAL | 1 | 2 | 4 - A | 4 - B | 4 - C | | 3 |
|---|---|---|---|---|---|---|---|---|
| *Student Score* | 15 | 0 | 5 | 5 | 0 | 5 | | 2 |
| " | 17 | 2 | 0 | 5 | 5 | 5 | | 2 |
| " | 2 | 0 | 2 | 0 | 0 | 0 | | 2 |
| " | 2 | 0 | 0 | 0 | 2 | 0 | | 2 |
| " | 2 | 0 | 2 | 0 | 0 | 0 | | 3 |
| " | 1 | 0 | 1 | 0 | 0 | 0 | | 2 |
| " | 0 | 0 | 0 | 0 | 0 | 0 | | 2 |
| " | 1 | 0 | 1 | 0 | 0 | 0 | | 2 |
| " | 4 | 0 | 2 | 2 | 0 | 0 | | 2 |
| " | 0 | 0 | 0 | 0 | 0 | 0 | | 2 |
| " | 0 | 0 | 0 | 0 | 0 | 0 | | 3 |
| " | 1 | 0 | 1 | 0 | 0 | 0 | | 2 |
| " | 1 | 0 | 1 | 0 | 0 | 0 | | 2 |
| " | 10 | 5 | 5 | 0 | 0 | 0 | | 2 |
| " | 0 | 0 | 0 | 0 | 0 | 0 | | 1 |
| " | 4 | 0 | 0 | 2 | 2 | 0 | | 1 |
| " | 0 | 0 | 0 | 0 | 0 | 0 | | 3 |
| " | 0 | 0 | 0 | 0 | 0 | 0 | | 3 |
| " | 0 | 0 | 0 | 0 | 0 | 0 | | 2 |
| " | 1 | 0 | 1 | 0 | 0 | 0 | | 1 |
| | | | | | | | | |
| **Mean** | 3.05 | 0.4 | 1.1 | 0.7 | 0.5 | 0.5 | | 2.1 |
| **Std. Deviation** | 13.34 | 1.2 | 1.5 | 1.6 | 1.2 | 1.5 | | 0.6 |
| | | | | | | | | |
| Average % Score | **12.2** | | | | | | | |
| | | | | | | | | |
| Average Student Level | **2.05** | | | | | | | |

**Figure 6 - Pre-Test Results**

| QUESTION | TOTAL | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| *Student Score* | 97 | 5 | 5 | 5 | 5 | 15 | 25 | 37 |
| " | 98 | 5 | 5 | 5 | 5 | 15 | 23 | 40 |
| " | 88 | 2 | 5 | 0 | 5 | 15 | 25 | 36 |
| " | 78 | 5 | 5 | 5 | 5 | 15 | 20 | 23 |
| " | 100 | 5 | 5 | 5 | 5 | 15 | 25 | 40 |
| " | 95 | 5 | 5 | 0 | 5 | 15 | 25 | 40 |
| " | 100 | 5 | 5 | 5 | 5 | 15 | 25 | 40 |
| " | 100 | 5 | 5 | 5 | 5 | 15 | 25 | 40 |
| " | 100 | 5 | 5 | 5 | 5 | 15 | 25 | 40 |
| " | 95 | 5 | 5 | 5 | 5 | 15 | 25 | 35 |
| " | 100 | 5 | 5 | 5 | 5 | 15 | 25 | 40 |
| " | 100 | 5 | 5 | 5 | 5 | 15 | 25 | 40 |
| " | 100 | 5 | 5 | 5 | 5 | 15 | 25 | 40 |
| " | 60 | 5 | 3 | 0 | 0 | 15 | 23 | 14 |
| " | 99 | 5 | 5 | 5 | 5 | 15 | 25 | 39 |
| " | 97 | 5 | 5 | 5 | 5 | 15 | 23 | 39 |
| " | 100 | 5 | 5 | 5 | 5 | 15 | 25 | 40 |
| " | 100 | 5 | 5 | 5 | 5 | 15 | 25 | 40 |
| " | 100 | 5 | 5 | 5 | 5 | 15 | 25 | 40 |
| " | 93 | 5 | 5 | 5 | 5 | 15 | 25 | 33 |
| " | 52 | 5 | 5 | 5 | 3 | 15 | 0 | 19 |
| | | | | | | | | |
| **Mean** | 92.95 | 4.9 | 4.9 | 4.3 | 4.7 | 15 | 23 | 36 |
| **Std. Devation** | 13.44 | 0.7 | 0.4 | 1.8 | 1.2 | 0 | 5.5 | 7.6 |

**Figure 7 - Evaluation Exam Results**

The validity of a test is primarily focused on content validity. This is the degree to which the test actually measures the intended content area. There were two steps taken to insure the content validity of the test. First, the exam was developed in the design phase. By using the design technique Developing Performance Objectives from Test Items the exam questions were sure to match the instructional objectives. The second process was to verify the questions with content experts. The expert determines whether or not the questions are relevant and suitable for the testing of the instructional unit. Jim Sochinski was the expert who reviewed the exam and approved the questions.

The reliability of the exam is the degree that it consistently measures what it is intended to measure." To accomplish this, statistical procedures are applied to the test results. Gentry proposes using a technique that involves the Kuder-Richardson formula 21. However since the evaluation exam items were not scored dichotomously, the Cronbach Alpha formula was used. A dichotomous test item is one that only has two possible scorings. Such an item would be a True-False test item. In the SFS evaluation exam, individuals were given partial credit. This necessitated the use of the Cronbach formula, which is pictured in Figure 6.

**Formula:**

$$\alpha = \frac{K}{K-1}\left[1 - \frac{\sum \sigma_i^2}{\sum \sigma_i^2 + 2\left(\sum \sigma_{ij}\right)}\right]$$

**Where:**

k = # of items

$\sum \sigma_i^2$ = sum of item variances

$2\left(\sum \sigma_{ij}\right)$ = 2 times the sum of the covariances OR (total variance of the Test - sum of the item variances)

**Figure 8 - Cronbach Alpha Formula**

The alpha statistic gives use "a percentage of the variance in the observed scores that is free from error" (Ary, Jacobs, & Razavieh, 1996). A consultation with Dr. Patricia Bickley of Educational Research recommended that the reliability for the evaluation test be evaluated in separate sections. This was due to the difference in scoring questions 1 - 6 and question 7. Questions 1 - 6 were all based on 5 point questions, and Questions 7 consisted of 12, 3.3 point answers. Questions 5 and 6 were multi-part questions, however each part was designed to be broken down into 5 point components. Thus the reliability was calculated for those questions. Those results are in Figure 9.

Some interpretation of the tables might be necessary. In Figure 9, Question 5 appears as 5-A, -B, and -C for the three answers required. Question 6 is represented as 6-A, -D, -S, -R, and -G. The characters represent the separate parts of the answer - Attack, Decay, Sustain, Release, and Graph. In Question 7 pictured in Figure 10, there were 4 components of Synthesizer Assembly Line students were required to identify which are labeled 1 - 4. Each SAL component had 3 parts for the student to answer, the Component Name (C), an example (E) of the component, and a definition of the function (F).

| QUESTION | TOTAL | 1 | 2 | 3 | 4 | 5 - A | 5 - B | 5 - C | 6 - A | 6 - D | 6 - S | 6 - R | 6 - G |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Student Score* | 60 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| " | 58 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 3 | 5 |
| " | 52 | 2 | 5 | 0 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| " | 55 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 0 |
| " | 60 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| " | 55 | 5 | 5 | 0 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| " | 60 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| " | 60 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| " | 60 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| " | 60 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| " | 60 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| " | 60 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| " | 60 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| " | 46 | 5 | 3 | 0 | 0 | 5 | 5 | 5 | 5 | 3 | 5 | 5 | 5 |
| " | 60 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| " | 58 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 3 | 5 | 5 | 5 |
| " | 60 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| " | 60 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| " | 60 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| " | 60 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| " | 33 | 5 | 5 | 5 | 3 | 5 | 5 | 5 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | | | |
| Mean | 57 | 4.9 | 4.9 | 4.3 | 4.7 | 5 | 5 | 5 | 4.8 | 4.6 | 4.8 | 4.7 | 4.5 |
| Variance | 40.86 | 0.4 | 0.2 | 3.1 | 1.3 | 0 | 0 | 0 | 1.1 | 1.4 | 1.1 | 1.3 | 2.2 |
| Std. Dev. | 6.392 | 0.6 | 0.4 | 1.7 | 1.1 | 0 | 0 | 0 | 1.1 | 1.2 | 1.1 | 1.1 | 1.5 |
| | | | | | | | | | | | | | |
| ∑ Item Var. | 12 | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Cronbach α | **0.77** | | | | | | | | | | | | |

**Figure 9 - Reliability for Test Questions 1 - 6**

| QUESTION | TOTAL | 1 - C | 2 - C | 3 - C | 4 - C | 1 - E | 2 - E | 3 - E | 4 - E | 1 - F | 2 - F | 3 - F | 4 - F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Student Score* | 36.67 | 3.3 | 3.3 | 0 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| " | 40 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| " | 35.33 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 1 | 3.3 | 1 | 3.3 |
| " | 23.33 | 0 | 0 | 0 | 0 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 0 |
| " | 40 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| " | 40 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| " | 40 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| " | 40 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| " | 40 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| " | 34.33 | 3.3 | 3.3 | 0 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 1 | 3.3 |
| " | 40 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| " | 40 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| " | 40 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| " | 13.33 | 3.3 | 0 | 0 | 3.3 | 3.3 | 0 | 0 | 3.3 | 0 | 0 | 0 | 0 |
| " | 38.67 | 3.3 | 3.3 | 2 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| " | 38.67 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 2 | 3.3 | 3.3 |
| " | 40 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| " | 40 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| " | 32 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 0 | 1 | 1 | 3.3 |
| " | 16.33 | 0 | 0 | 0 | 0 | 3.3 | 3.3 | 3.3 | 3.3 | 1 | 1 | 0 | 1 |
| " | 40 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 |
| | | | | | | | | | | | | | |
| Mean | 35.65 | 3 | 2.9 | 2.5 | 3 | 3.3 | 3.2 | 3.2 | 3.3 | 2.8 | 2.9 | 2.7 | 2.9 |
| Variance | 61.16 | 1 | 1.4 | 2 | 1 | 0 | 0.5 | 0.5 | 0 | 1.3 | 0.9 | 1.4 | 1.1 |
| Std. Devation | 7.82 | 1 | 1.2 | 1.4 | 1 | 0 | 0.7 | 0.7 | 0 | 1.1 | 1 | 1.2 | 1.1 |
| | | | | | | | | | | | | | |
| ∑ Item Var. | 11.05 | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Cronbach α | **0.89** | | | | | | | | | | | | |

**Figure 10 - Reliability for Test Question 7**

A calculation of the Cronbach Alpha score for questions 1-6 and 7 revealed a very high reliability. Questions 1 - 6 received a score of .77, and question 7 scored .89. This high reliability increased the support for the finding that the test was consistently showed students had made significant achievement.

With a high average mean and low standard deviation, it was estimated that students made significant gains in achievement. The tests also showed to be quite reliable. However, the results are prone to some error. Students were aware that the pre-test scores were not counted as grades for them. This could cause the scores to be lower than expected if students did not treat the pre-test seriously. Additional bias by the researcher could also have affected results since he was the designer, instructor, and evaluator. This source of error was hoped to be minimized by reviewing all design, implementation, and evaluation issues with experts. Taking into account sources of possible error, it was still assumed that the Synthesis Fundamental Seminar was successful in communicating the instructional material.

## 4.0 Summary

Gustafson and Tillman (1991) point out that it is important that instructional designs be empirically tested. Instructional theory is at an early stage of development and requires actual implementation to test the effectiveness of the design. This research was the first phase of testing the Instructional Project Development and Management (IPDM) model. As previously stated, this research had a limited scope as well as limited resources. This also means that the generalizability was reduced. It is hoped that the additional research can be conducted under more thorough circumstances to attain more generalizable results. However, this study proved to be an excellent preliminary experiment which should make subsequent studies much more efficient.

At a general level, the Instructional Program and Development Model as presented by Castelle Gentry (1994) is an efficient and comprehensive instructional design model. The model covered all of the necessary processes involved to implement an instructional unit. Several times the model showed itself to be extremely effective in providing a direction for development. By starting at the Needs Analysis phase and preceding clockwise around the diagram, it was clear when each step should be taken. It also emphasized that development is rarely a linear process. Often backtracking was required as development in one phase necessitated revision of another. This process could often cause a rippling effect, and several phases would have to be revised. This also demonstrated interrelationships of the components.

It would be the recommendation of this researcher to recommend this model to future studies with a scope similar to this one. The effectiveness of the IPDM model for larger studies cannot be assumed from this research.

However, the thoroughness and diversity of techniques presented by Gentry (1994) would make it a good candidate for instructional units of all sizes.

# 5.0 Appendix

### Appendix A-1 - Delphi-Style Questionnaire

This is a series of questions designed to better focus the design of a seminar in electronic music synthesizer programming. The seminar is to be implemented in the early spring of 1996.

I would appreciate a response within two weeks. Please contact me if you have any further questions.

Thank you,

Christian Fowler
magma@acm.vt.edu

1. What components of synthesizer programming do you consider necessary for successful teaching of the basics of synthesizer programming?

2. What areas would you consider irrelevant to a discussion on fundamental synthesizers?

3. To whom do you consider this instruction should be directed? (i.e. Academic level of students)

4. What level of knowledge would you consider an individual to have in the area of Music? Computers? and Synthesizer Manipulation?

5. What tasks would you consider the student to be able to accomplish at the completion of the seminar?

## Appendix A-2 - Replies to Delphi-Style Questionnaire

>1. What aspects of synthesizer programming do you consider necessary for
>successfully teaching the basics of synthesizer programming?

Knowledge of how synthesis elements (envelope, modulation, etc.) effect sound. Basic voice architecture of the synth.

A BASIC UNDERSTANDING OF MUSICAL ACOUSTICS AND SOUND AND HOW IT RELATES.
A BACKGROUND IN THE DIFFERENT TYPE OF SYNTHESIS AS USED BY THE MANUFACTURERS SUCH AS OSC. BASED
ADDITIVE / SUBTRACTIVE SYNTHESIS / PCM / FM, AND SO FORTH.
FILTERS, ENVELOPES (ANALOG AND EARLY ANALOG / DIGITAL HYBRIDS)
AN ATTEMPT TO CENTRALIZE AN UNDERSTANDING OF SUBJECTIVE TERMS USED IN
TALKING ABOUT SOUND (SUCH AS FAT, SIZZLY, WET, ETC.)

>2. What areas would you consider irrelevant to a discussion on
>fundamental synthesizers?

Anything beyond aspects given in No. 1

I CANT THINK OF ANY RELATED TOPIC (TO SYNTHS) THAT WOULD BE IRRELEVANT.

>3. To whom do you consider this instruction should be directed? (i.e.
>Academic and knowledge level of students)

Sophomore-level music students.
With basic music skills (notation, pitch perception, performance experience, ensemble experience)

HS, EARLY COLLEGE, THOSE WITH EXPERIENCE OR DIRECT INTEREST.
PEOPLE WHO EXPERIMENT AND LEARN ON THEIR OWN AS WELL

>4. What level of knowledge would you consider an average student to have
>in the area of Music?

Computers?
Just user experience (not necessarily programming experience)
and Synthesizer Manipulation?
None

AVERAGE STUDENT? DOES THIS MEAN MUSIC STUDENT? IS THIS PRIOR, DURING, OR
AFTER THE COURSE?

>5. What tasks would you consider the student to be able to accomplish at
>the completion of the seminar?

Edit existing voice to change to a prescribed state (e.g. "brighter, with a sharper attack")
Create a new voice to spec.

BE ABLE TO EXPLAIN TO JOHN DOE THE BASICS OF HOW A SYNTH PRODUCES SOUND.
(VARIOUS METHODS) BE ABLE TO RELATE ENVELOPES TO ACOUSTICAL SOUNDS
BE ABLE TO TRY AND SIMULATE SOUNDS BASED ON "REAL ACOUSTIC" MODELS AND/OR
VERBAL DESCRIPTIONS

## Appendix B-1 - *Test Questions, PRE-TEST*

Q: What is sound?

A: Sound is the repeated compression and decompression of particles.

Q: What two things must be present for sound to occur.

A: A vibrating body and a median to travel through.

Q: Rate your knowledge of synthesizers:

- ∞ Don't know anything
- ∞ I can turn on the power and switch patches, that's about it.
- ∞ I know how to fully *use* the synth, including accessing multiple MIDI channels. I don't know how to program it.
- ∞ I know what the major sound generating components are and can semi-efficiently tweak the sounds.
- ∞ I am a programming whiz - I can quickly edit or create any sound that I desire.

Q: Name 3 primary components included in most synthesizers.

A: Oscillator, Envelope, Control Source

**Appendix B-2 - *Evaluation Test***

**MUS 2054** **NAME _______________**

# Synthesizer Fundamentals Quiz

1. What is sound? [ 5 points ]

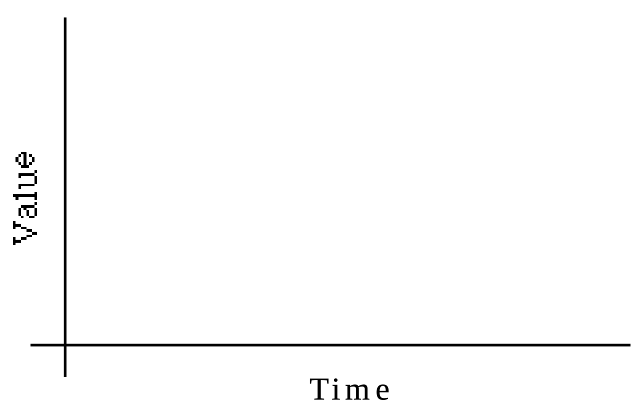
2. What two things must be present for sound to occur. [ 5 points]

3. What is the 4 harmonic of 110 Hz ? [ 5 points]

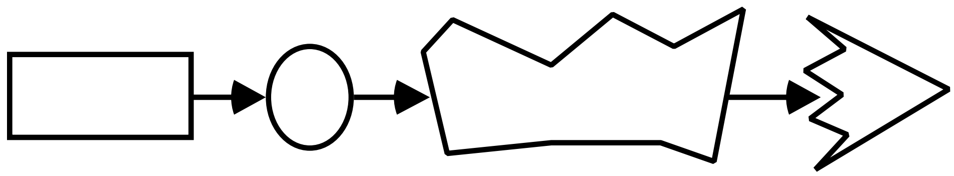
4. What waveform has no harmonics? [ 5 points ]

5. Name 3 three waveforms that are well-suited for synthesis? [15 points ]

6. Draw a picture of a typical ADSR envelope and label its components [ 25 points ]



7. Name the four primary components of the Synthesizer Assembly Line, list its function, and give and examples of each. [ 40 points ]



Component

Example

Function

## Appendix C-1 - Presentation Slides

# The Fundamentals of Synthesis

### The Origin of Sound

**n What is Sound?**

- Sound is simply the repeated fluctuation of particles.

### The Origin of Sound

A vibrating body causes the compressing and decompressing the particles. For air particles, this causes a fluctuation in air pressure.

**n The fluctuation in air pressure is perceived by our ears and communicated to our brain which interprets these fluctuations.**

### The Origin of Sound

**n Two things must be present for sound to occur:**

1. A vibrating body
2. A medium to travel through

### The Motion of a Vibrating Body

Steps 1 through 4 represent a string, such as that on a violin, however, the same behavior would occur for many other bodies such as reeds, drum heads or even speaker cones.

### The Motion of a Vibrating Body

**n The string is stationary. The pressure is equal on both sides of the string.**

### The Motion of a Vibrating Body

The string is pulled to the right. This smashes the air particles together, creating an area of high pressure on the right, and low pressure on the left.

### The Motion of a Vibrating Body

Once the string has reached its maximum displacement, it will move back towards the center. At the exact center, the pressure will once again be equal on both sides. However, since it is in motion it will continue to move to the left.

### The Motion of a Vibrating Body

The string will reach a maximum displacement again, nearly opposite of when it moved to the right. This will also create areas of high and low pressure, just as before, except the high pressure will be on the left, and the low pressure on the right.

**The Motion of a Vibrating Body**

The string will return to the middle, just as before. It will continue this process over and over again until it stops due to friction.

**The Motion of a Vibrating Body**

The time it takes a vibrating body to move through steps 1 - 4 one time is called a **cycle**. The number of times the vibrating body repeats this cycle in one second is the **frequency**. The unit of frequency is the **Hertz**.

**Waves**

- **A wave is the pattern produced from the fluctuation of particles.**
  - The graphical representation of the wave is called a waveform.
- **The most simple waveform that can be generated is a sine wave.**
  - It produces just one frequency. This is similar to the sound produced by a tuning fork.

**Waves**

The sine wave does not occur naturally. By itself, it is not very useful in musical applications. However, sine waves can be stacked together to produce more complex waveforms.

**Waves**

For example, we could take a sine wave with a frequency of 440 Hz, which is Concert A. We can then produce another waveform that is exactly twice the frequency of the Concert A, which is 880 Hz. By adding even higher multiples of 440, the sine waves will blend together to form a single tone.

**Harmonics**

- **The most predominate frequency is typically responsible for giving a sound a pitch.**
  - This is called the **Fundamental Frequency**.
  - This is often the lowest frequency.
- Overtones **are frequencies that occur above the fundamental frequency.**
- Undertones **are frequencies that occur lower than the fundamental frequency.**
  - They occur much more less often that overtones.

**Harmonics**

- **A harmonic is an overtone that is has a frequency which is an even multiple of the fundamental.**

**Harmonics**

To calculate harmonics, the fundamental frequency is just multiplied by an positive integer. If our fundamental is 110 Hz, the first harmonic is

- **110 Hz x 1 = 110 Hz**

n**This is the same as the fundamental. This is an important point**
- u *The first harmonic is always the fundamental frequency.*

**Harmonics**

n**The first 9 harmonics for a fundamental frequency of 110 Hz -**

**Waveforms**

**The Synthesizer Assembly Line**

**The S.A.L. - The Control Source**

n**The main function of the control source is to give the synthesizer engine information on how to produce a sound.**

n**This information can be the pitch of the sound, the loudness of a sound, or many other possibilities.**

**The S.A.L. - The Control Source**

n**Several common controllers are:**
- Keyboard
- Electronic Wind Instruments
- Guitar Controllers
- Computers

**The S.A.L. - The Sound Generator**

n**The sound generator produces the initial waveform, or sound, with an electronic circuit called an** oscillator**.**

n**The heart of any synthesizer is the oscillator.**

**The S.A.L. - The Sound Generator**

n**An Oscillator can be**

**Voltage-Controlled Oscillator** (VCO) - an electronic circuit produces electrical alternating voltages. It is used primarily on analog synthesizers.
- **PCM Samples** - A digital recording of a sound is used as the primary sound source. It is used in most modern synthesizers.
- u **Mathematical Equations**

**The S.A.L. - The Sound Modifier**

n**The sound modifier is the crucial part of the synthesizer that converts a stagnant, boring tone, in a dynamic, musical timbre.**

n**There are three primary sound modifiers:**
- Filter
- Amplifier
- Modulation

**The S.A.L. - The Sound Modifier**
***Envelopes***

n**An envelope generates values that control the sound modifiers over time.**
- They increase or decrease the amount of a certain parameter in a sound.
  - For example: amplifiers, modulators, filter cutoff frequency, or pitch.

**The S.A.L. - The Sound Modifier**
***Envelopes***

n**Envelopes are characterized by the number of** stages **they have. Each stage is defined by a change in direction.**

n**The most common type of envelope is the Attack-Decay-Sustain-Release, or ADSR envelope.**

**The S.A.L. - The Sound Modifier**
***Envelopes***

n**The 4 most common points on an envelope are:**
- **Attack** - the time it takes for the envelope to go from a zero value to its peak value
- **Decay** - the rate at which the sound decays from the maximum attack value to the sustain level
- **Sustain** - adjusts the level at which the decay stops, and that value is held.
- **Release** - the amount of time it takes to go from a positive value to zero.

**The S.A.L. - The Sound Modifier**
***Filters***

A **filter** is an electronic circuit that is sensitive to different frequencies. A filter is designed to let certain frequencies pass, while blocking others.

**The S.A.L. - The Sound Modifier**
***Filters***

n**There are 3 primary types of filters**

- **High Pass** - Only frequencies ABOVE cutoff frequency may pass.

- **Low Pass** - Only frequencies BELOW cutoff frequency may pass.

**Band Pass** - There are TWO cutoff frequencies - an upper and lower. Only frequencies BETWEEN the two cutoff frequencies may pass.

**The S.A.L. - The Sound Modifier**
***Filters***

nResonance **emphasizes or “boosts” are narrow band of frequencies**
- It gives a synthesizer a uniquely “synthetic” sound

**The S.A.L. - The Sound Modifier**
***Amplifiers***

nAmplifiers control the volume of the oscillator output. This is done through the use an amplitude, or volume envelope.**

**<u>The S.A.L. - The Sound Modifier</u>**
***<u>Modulation</u>***

**nModulators modify a sound, typically in a rhythmic, repeating fashion.**

- It used most often to add expression and effect to a sound. Example: vibrato

Synthesizers often use special oscillators to perform modulation called a **low frequency oscillator** , or **LFO**. LFO's can typically generate waveforms from 1 - 20 Hz.

**<u>The S.A.L. - The Sound Output</u>**

**nThe sound output converts the musical tone a signal that can be plugged into a sound system.**

**Mixing** - modern synthesizers have dozens of oscillators, so a mixing circuit is added to combine the many generated tones into a couple of outputs.

**Amplification -** the sound passes through a preamplifier because the initial output is not powerful enough to drive the inputs of an sound system.

**<u>The Synthesizer Assembly Line</u>**

## 6.0 Bibliography


Ary, D., Jacobs, L. C., & Razavieh, A. (1996). Introduction to Research in Education. Fort Worth, TX: Harcourt Brace College Publishers.

Briggs, L. J., Gustafson, K. L., Tillman, M. H. (Eds.). (1991). Instructional design: Principles and applications. Englewood Cliffs, NJ: Educational Technology Publications.

Fleming, M. and Levie, W. H. (1993). Instructional message design: Principles from the behavioral and cognitive sciences. Englewood Cliffs, NJ: Educational Technology Publications.

Gentry, C. G. (1980). A management framework for program development techniques. *The Journal of Instructional Development* 4(2): 33 - 37.

Gentry, C. G. (1994). Introduction to instructional development: Process and technique. Belmont, CA: Wadsworth Publishing Company

Hamilton, R. & Ghatala, E. (1994). Learning and Instruction. New York, NY: McGraw Hill, Inc.

Smith, P. L. & Ragan, T. J. (1993). Instructional design. New York: Macmillan Publishing Company.

Taylor, R. and Doughty, P. J. (1988). Instructional development models: Analysis at the task and subtask level. *The Journal of Instructional Development* 11(4): 19 - 28.

## 7.0 Index

## 8.0 Vita

Christian Fowler was born in Fairfax, VA in 1972. He lived in Leesburg, VA most of his youth and graduated from Loudoun County High School in 1990. He received his Bachelor of Science degree in Computer Science from Virginia Tech in 1994. He decided to not aggressively pursue a career. Instead he chose to follow a girl named Leslie Fowler (no relation) wherever she went. Leslie, a VT Mechanical Engineer, decided to pursue a master's degree at VT. So, knowing he was to be in Blacksburg for an additional 2 years, Christian decided to enroll in the Educational Technology graduate program. He finished his degree in April, 1996. He will probably get a job doing Multimedia and WWW related programming and development. He is also an avid fan of electronic and other strange ambient music. Perhaps he will work as musician or in a recording studio. He will moving to Erie, PA, still following the girl, though she shall be his wife. There he goes in this thing called life, following a girl named Leslie.

Christian Fowler