More Micro in Your Micro

The Use of Design Principles to Develop Instruction for a Small Group of Highly Advanced General Microbiology Students

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Introduction to Instructional Design

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The Situation

General Microbiology is a two thousand-level class taught at the University of Wyoming. Students in this course are predominantly Sophomores and Juniors seeking degrees in a biological science. Most students have appropriate prerequisites including General Chemistry and General Biology. The class has both a lecture and laboratory component. Lectures are delivered three times a week; labs meet twice a week. In lecture, assessment is via three semester exams, a final exam, homework and a poster project. In lab, quizzes, reports and practical exams constitute the grade. As the instructor for both the lecture and laboratory components of the course, I have seven or more face-to-face hours of contact weekly with all of the students. In addition, I interact with students on the eCompanion course shell in order to discuss additional questions, extra credit critical thought assignments and optional book discussions.

This semester, in the week following the first exam I identified a problem that I had not encountered before. I recognized two students, in particular, who where far and away more advanced than the remainder of the class. My interactions with these two students were in both the face-to-face and online environments. In a very short period of time I had recognized that their prerequisite knowledge was extensive, they had fairly well developed critical thinking skills and were creative. I became very concerned that they would be unable to thrive, to extend their cognitive capacity, with the traditional class format. Thus, worried by this and also armed with newly acquired instructional design knowledge I decided to offer an opportunity to the entire class. The following announcement was made at the beginning of two consecutive lecture sessions:

I am seeking a small group of intrepid individuals for a teaching and learning adventure.

Contact me if...

-you already feel comfortable with much of the material presented in any given lecture.

-you are fairly certain you can get an A on every exam with very little time spent studying.

-you don't mind investing more time in the class.

-you like problem-based, applied learning that pushes you to a new level of critical thought and synthesis.

-you like challenges and are ready to "take it to a whole new level".

I hoped that the two previously-mentioned students would self-identify as appropriate members. They were, in fact, the first two to respond. They were followed by two more students to round the group out to four. Thus, we began an instructional design project that we decided to call More Micro in Your Micro or simply More Micro for short. We wanted to replace traditional exams with online critical thought discussions and writing. The following description describes the underlying philosophies of design/teaching, the instructional model used, the instructional analysis, the organizational and delivery strategy, the learning task analysis, and the actual assessment items used.

Underpinning Philosophies of Teaching and Learning

The design of instruction for this project was guided/informed by several underlying philosophies of teaching and learning. Each of these philosophies provided rational for certain components of the design. Table 1 summarizes the philosophies influencing my design decisions as both the instructor and designer. Also noted in the table are components of the design for which each philosophy provided rational.

Teaching/learning Philosophy	**Important element/s of this philosophy to the current design project**	**Component of the design for which this philosophy provided rational**
Social Cognitivism	Instructor as a role model Learner is Self-directed and is locus of control (Merriam, 2008)	Active instructor contribution in discussion threads, where instructor modeled critical thought, synthesis, assessment etc… Learners determined goals, posed discussion questions, chose approach to addressing and summarizing questions
Humanism	Student-centered learning Learner is Self-directed (Merriam, 2008)	Learners developed goals, posed the questions that drove discussions, Learner-centered instructional development model used (PIE Model)
Feminism	Learning through dialogue Learning that is Not value-neutral (Roy, 2004)	Discussions served as the primary learning forum and the effects of science on people were not ignored
Moderate Social Constructivism	Collaborative learning (Smith and Ragan, 2005)	Threaded discussions were in groups, summaries were written collaboratively

Table 1: Underpinning philosophies and their role in design of More Micro instruction

Instructional Model

The model used to guide this project was the Newby, Stepich, Lehman and Russell (2000) Model as reviewed by Gustafson and Banch (2002). Another name for this model is the PIE model as it is characterized by three phases: Plan, Implement and Evaluate. This is a classroom-oriented instructional development model and encourages the shift from a teacher-centered to a learner-centered classroom. This model encourages the use of technology which was also very fitting to

the current design project as instruction was to be entirely online using an online classroom management system (eCompanion) and a Web 2.0 tools (e.g. Google Documents). Table 2 presents a PIE matrix that was developed using questions suggested by Gustafson and Branch as well as questions important to me, as the instructor. In addition to the student-centered approach inherent in the model, further emphasis was placed on truly attempting to empower the learner in the learning process.

	Plan	**Implement**	**Evaluate**
Learners	*What role will the learners play during instruction? What do the learners already know (what competencies do they have)? What is their grade level? What is their cultural background? What role in instruction are they used to having and what role would they like? What special talents (background knowledge) do they bring to the class? What are the students interests/future plans, beliefs and values? Will the students determine learning objectives? What are these objectives?*	*How will students know they are learning? How will students ensure an active role in their learning?*	*Did students accomplish / feel that they accomplished their learning objectives? Were students satisfied with the role that they played in forming and guiding learning objectives? Did students feel that instruction was personalized to them? Did students feel that their background was acknowledged (cultural / knowledge of subject material / talent)?*
Teacher	*What role will the teacher play? Will the teacher determine the learning objectives? What are these objectives?*	*How is the classroom managed? To what extent are students given feedback /motivators/challenges to paradigms? How is focus maintained on student and teacher learning objectives?*	*Did the teacher accomplish / feel that he/she accomplished the learning objectives? Was the instructor satisfied with the role she/he played in forming and guiding learning objectives? Was the instructor satisfied with her/his role in providing feedback / motivation / challenges to paradigms? Was the instructor satisfied with the focus maintained (throughout implementation) on goals?*
Instructional Technology (IT)	*What materials exist? What new technology could assist in reaching objectives? Could technology assist in making the planning /design more efficient?*	*Can technology be used to increase instructional impact / maintain engagement / provide unique forums for individual student expression and social interaction?*	*Did learners feel that technology enhanced their learning / feelings of engagement? Did they feel it gave them an individual forum for expression as well as a social forum for learning? How might the technology be improved? Can technology be used to measure effectiveness, efficiency and appeal of instruction?*

Table 2: The PIE Model as applied to More Micro ID

The answers to most of these questions were addressed throughout the design process as descried in the ensuing sections.

Instructional Analysis

A formal needs assessment was not conducted but both the learning environment / ”system” and the learners were analyzed.

The learning environment/”system” (Smith & Ragan, 2005, p. 49)

As I was both designer and teacher, several aspects of the learning environment analysis were simplified. Earlier assessments of underpinning learning and teaching philosophies as well as choice of instructional model largely address questions of teacher interest and preference. However, several of the questions in the PIE matrix relate to this and should be specifically addressed: *What role will the teacher play? How is the classroom managed? To what extent are students given feedback /motivators/challenges to paradigms? How is focus maintained on student and teacher learning objectives? What role will the learner play? What (IT) materials exist?*

What role will the teacher play? How is the classroom managed? To what extent are students given feedback /motivators/challenges to paradigms? How is focus maintained on student and teacher learning objectives?.

Inherent in these questions is the consideration of the type of instructional strategy being used. As the learners had high aptitude / extensive prerequisite knowledge (see learner analysis below), the planned instructional strategy was more generative (learner determined) than supplantive (provided by the instruction). However, certain events of instruction were more supplantive and

thus the role of the teacher changed accordingly. For example, all students in this instructional group were asked to attend lecture three days a week. In this environment a more supplantive strategy is used and the teacher (myself) takes responsibility for the first step of the body of instruction "stimulating recall of prior knowledge" (Smith & Ragan, 2005, p. 130). This also served to gain learners' attention and stimulate motivation. Also, as reflected in the above discussion of teaching and learning philosophies, I wanted to play an active role in discussions. Great value is present in instructor role modeling particularly when the content itself has very high "intrinsic load" (Smith & Ragan, 2005, p. 144). In addition, growth in learning is assisted when paradigms are challenged and when the teacher asks students to reconsider their standpoint. In my activity in the discussions, I also wanted to play this role. In essence this really is a more supplantive strategy for the body of instruction in which I hoped to model learning strategies. However, throughout discussions and syntheses of summaries, I saw the most important teaching role as reminding learners of our learning objectives and continuing to redirect discussion and writing towards accomplishment of those objectives. That is, a more supplantive strategy was used to redirect students' attention throughout the body of instruction. In my role as teacher I also wanted to provide cumulative feedback (both motivational and informational) throughout the course of instruction.

Because the instruction that occurred in the More Micro group supplemented traditional lecture and homework assignments, a generative strategy was possible in that instructional time was not limited (Smith & Ragan, 2005). In fact, in the opening discussion thread I made sure to inform the learners that we would not rush to accomplish our goals. I wanted us to accomplish our goals but without the stress of rigid due dates and time frames. My posts and e-mails frequently included phrases such as, "Within the next few days let's try to…". I also wanted to

individualize instruction and this was only possible if I made active and often contributions to the discussion helping learners see application of the content to their interests. Please see Appendix 1 for an example of a More Micro group discussion thread and the involvement that I had as the teacher.

What (IT) materials exist?.

The eCompanion classroom management system is already used by the General Microbiology class for homework, extra credit and book discussions. Thus this was chosen as the learning environment for a majority of the instruction for the More Micro group. Students can readily access computers on campus at any time.

The learners

As mentioned in the synopsis of the situation above, it was in part prior evaluation of the learners that inspired development of instruction. So certain learner characteristics were assessed prior to the formal instructional analysis. However, in order to learn more about the learners, certain questions were asked in the initial discussion thread. As consideration of stable similarities (learner characteristics that stay basically the same with time) is inherent in all facets of the course and because conditions of learning have been separately considered, an entire section is not devoted to them here. However, changing similarities (similarities between learners that do change with time) stable differences (individual differences that remain largely the same over time) and changing differences (individual differences that change over time) are considered (Smith & Ragan, 2005). As mentioned above, information about learners was garnered through interaction but also through a series of questions included on the first

discussion thread (see appendix 2 for this thread). The following sections attempt to summarize these findings and the questions from the above PIE model are included beside the section heading.

Changing similarities

The previous consideration of teaching and learning philosophies largely considers approach with respect to intellectual development. However, psychosocial stage of development stage was considered. Because learners were asked to self-identify as appropriate members of the group, this inherently allowed me to assess certain aspects of their development. For example, students self-identified as being comfortable with all aspects of the lecture material and saw themselves as capable of easily earning an A on all exams. Thus with respect to Maslow's Hierarchy of needs, I felt fairly comfortable categorizing these learners as meeting, in most cases their esteem needs (Maslow, 1954). I did hope that instruction could assist learners to with certain aspects of their self-actualization needs, particularly problem solving and creativity.

Stable Differences

What do the learners already know (what competencies do they have)? What is their grade level? What special talents (background knowledge) do they bring to the class? What is their cultural background?.

Students' aptitudes (readiness for instruction) were determined to be very high by my previous interaction with students and assessment via the first lecture exam (see situation, above). Also as mentioned previously, self-selection into the group made transparent students' high academic self-concept. Grade level varied from one sophomore to one non-traditional

student with a previous Bachelor's degree in geology and experience in the workforce. Serendipitously, gender equivalency was reached in that two female and two male students self-identified.

Backgrounds and talents also ranged and really this diversity was the commonality of the group! In all cases, members had been in another area before choosing to study micro/molecular biology. Two had a background in / knowledge of music. Two spoke other languages. All had interests in diverse areas. One student commented, "I love science because the natural world blows my mind but art and music touch my soul, politics revs me up and math make me humble…. I am wicked diverse in my races, religions, dietary restrictions, financial exclusionisms, social inclusionisms, islamo fascinationisms and ethno-hetero virtuosity(s)."

Interestingly prior to creation of the More Micro group, during the period of time when I recognized the high aptitude of these learners, I also noted an extreme face-to-face shyness which contrasted with what could only be termed bubbling enthusiasm for social interaction in the online environment. I thus categorized this as a type of anxiety, which seemed to be alleviated by careful consideration of learning environment. Also based on learners self-selection under the request that they not mind investing extra work and wanted to "take it to a whole new level" as an indicator of learners' having an internal "locus of control" (Smith and Ragan, 2005, p. 63) / are perseverant, assume success to come through effort.

Changing differences

What are the students interests/future plans, beliefs and values?.

It was extremely important to me to determine students' interests (future plans and dreams) and if they felt comfortable sharing them with me, their values and beliefs. Just as had

been true of the groups members' collective backgrounds, their interests were also diverse. One was interested in writing, two in medicine and one in the expansion into space and self-contained living systems. However, what united them was a hope for improvement, a hope to help society through science. One student commented, "I plan to operate on the premise that the world around us exists in discrete quantities, and that these can be manipulated. I think this includes the mechanics we move around in, and that there's room for improvement, both by "reading the user manual" (e.g. understand what makes us tick, properly maintain) and by direct improvement.". Another stated, "…my driving force is to make a positive impact in the world (be it a big one or a small one)."

Implications of Learner Characteristics for Design

What role will the learners play?

The above evaluation of learner characteristics, showed the members of the group to be of high aptitude, self-driven, and well-rounded. Thus, for many events of instruction a more generative strategy with a high level of learner control was evoked. For example, after having their knowledge activated by the lecture material, the learners naturally formulated questions that could be further discussed on online threads. By developing these questions and by determining their goals for the More Micro group, learners were, in effect, establishing the purpose of instruction. This is an important event in the introduction of instruction. After discussing these questions using scientific journal articles as background, learners summarized the findings. Thus, a generative strategy was used for the summary event when concluding instruction. As is discussed in more detail in the assessment section, students used a self-assessment strategy to allow them to determine if they were learning and if they were playing an active role in

instruction. Students also assisted in evaluating the feedback of their writing provided by outside readers (see assessment items section). Also, because two of the learners were assessed to be shy in face-to-face learning environments, an online platform was used to provide a safe environment for interaction without the anxiety of in-person interaction.

Learning task analysis

Will the students/teacher determine learning objectives?

Even before creating the first discussion thread for the More Micro group, I knew that I wanted to determination of learning goals to be a cooperative process. Thus, on our opening thread, I posed the question, "What do you want to learn in this group? What role would you like to take in your instruction?" I then took the initiative to be the first respondent to this question and related my goal to, "…create a forum that empowers students to define their own learning goals. I would then like to challenge myself to design instruction that will enable you all to achieve your own goals. I hope to activate your knowledge with the traditional lecture material, to help inspire you to ask larger questions, to then help facilitate your learning as you explore and discuss these questions and finally to be able to challenge your knowledge structures as you build them!" Students then added to the thread voicing their goals for the group. These varied but two students wanted to gain a deeper understanding for microbiology through problem-based learning and the other two expressed interest in applications of microbiology. One student took this to a higher level by expressing a specific interest in modeling design systems after microbial systems. He stated, "I think that there's a number of problems that can be bettered by a greater understanding of microbes, and I'd like to gain insight into these. Basically anything people need to do would work much better as a cycle, with end-products returning as inputs. I think it stands

to reason that understanding microorganisms is vital to accomplishing this." One student also clearly expressed a goal of wanting to write about science in terms that non-scientists could understand.

After reading through the goals, I tried to consolidate them into a list of general goals for our group. Following is the very rough list that was determined and posted on the thread:

FINAL GOALS (please add to this if you think it appropriate and as soon as we're all agreed we'll move on to our first discussion):

1) Come up with questions inspired by lecture. This need not be as structured as a true research question and may evolve as we learn by discovery.

2) Access, read, and discuss journal articles addressing our questions.

3) Write about the articles that we read in such a way that the general public can understand! I suggest we use a google doc or wiki so that we can all edit the document.

4) Discuss the applications of microbial life strategies to human innovation as they pertain to the given question.

5) Answer questions that the rest of the class might ask under the General tab (this would hit on the goal of explaining concepts)!

6) Most importantly - create a learning environment where all of you thrive (continue to grow like we hope Quintin's mango seedlings will do) (no stagnation - like I sense was happening in the traditional lecture).

This summarized the contribution that learners made to the learning objectives. From here, I took charge of modifying and streamlining these into true learning objectives according to Smith and Ragan's Instructional analysis suggestions. After a multitude of revisions the final learning objectives were consolidated into five categories: Inquiry, Research, Critical Thought, Writing

and Evaluating.

What are the Learning Objectives?

Inquiry.

Given background content in the form of the course lecture, learners will compose and submit (via e-mail) at least one question that correlates lecture material with prior knowledge and predicts (hypothesizes) possible further relationships between current lecture content and available literature.

Research.

Given a research question and access to the University of Wyoming Library's Web Site, Learners will be able to access at least one pertinent article, published in the last two years, using the Web of Knowledge Database.

Critical Thought.

Given microbiology journal articles, learners will be able to

-summarize the content of the article using their own words.

-discuss the content of the articles with peers.

-apply the journal articles to a research question.

-correlate the articles with current lecture material and prior knowledge, "elaborate" (Smith & Ragan, 2005, p. 142).

-speculate industrial/societal/scientific/ethical applications and implications of the journal content.

Writing.

Given an online, collaborative document, learners will be able to summarize research findings in such a way that non-expert readers (purposively sampled) all indicate a positive attitude toward the writing on a bipolar adjective scale.

Evaluation.

Given an open forum in which to express themselves, learners will report that they were satisfied with the intellectual growth enabled by the More Micro group.

What new technology could assist in reaching objectives? Could technology assist in making the planning /design more efficient?

All objectives relied heavily on technology. Questions upon which discussions were based were submitted via e-mail. The Research objective was made possible by the University of Wyoming's web site. All Critical Thought objectives were achieved via discussions on threads in the eCompanion course shell. In order to achieve the Writing learning objective, we used a Google Doc. This enables collaborative editing and contribution to a single word processing document. Non-expert readers of the students' summaries were e-mailed with the assessment document and the access information for the Google doc. Thus, technology was planned into nearly every aspect of the design.

Assessment Items

Did students/teacher accomplish their learning objectives?

Inquiry and Research Objectives

Assessment of the learning objectives was somewhat simplified by the extremely small group of students. In assessing the Inquiry and Research objectives, the ideas of Jane Vella were evoked in that I simply determined that learning objectives had been accomplished because students, just did it (Vella, 2002). They e-mailed or came directly to me with questions that had been inspired by recently-covered subjects in lecture. I determined whether these questions correlated lecture material with prior knowledge whether they predicted (hypothesized) possible further relationships between current lecture content and available literature. If the questions did not meet these requirements then I simply asked the students to give a bit more thought to the question and e-mail it to me in a more complete form. Similarly, when assessing the research objective, students simply were shown the Library web site and were asked to use the Web of Knowledge to find a pertinent article published in the last two years. If they posted about this article on the thread then I assumed the objective to have been accomplished.

Critical Thought Objectives

Assessment of Critical Thought and Writing objectives was a bit more complicated. Within the context of this particular group, the only assessment form with which I was comfortable was a rubric. Thus, using Bloom's Taxonomy (Bloom, 1956) and criteria suggested by the rubric for the Holistic Assessment of Critical Thinking across the Curriculum (Hooker, 2005), I developed the following rubric to assess the Critical Thought objectives:

Category	**Objective**	**Level**			
(based on Bloom's Taxonomy)	***Given microbiology journal articles, learners will be able to***	**beginning** (inaccurate, inappropriate, singular, illogical, fragmented)	**developing** (correct, appropriate, dualistic, reasonable, consistent)	**Competent** (accurate, relevant, multiplistic, logical, coherent)	**Accomplished** (precise, insightful, balanced, perceptive and unified)
Comprehension	summarize the content of the article using their own words.	*Fragmented, small pieces of article are restated, copied / directly quoted*	*Reports most obvious content in own words, difficult content copied, restated / directly quoted*	*Complete, unfragmented, presents a majority of the content in own words, makes transparent attempt to summarize difficult content but relies on direct quotes / restatements occasionally*	*Clear aptitude to summarize all content in own words, no shying away from difficult material, direct quotes used only when they are the most effective means of summary*
Comprehension	discuss the content of the articles with peers.	*lists ideas/opinion but with no interaction*	*Attempts interaction but over-simplifies positions*	*Interacts effectively, considers others positions but may not incorporate them into his/her thinking*	*Interacts thoroughly, considers and incorporates others positions, makes effort to further explain and elaborate (teach others)*
Application	apply the journal articles to a research question.	*Either application is completely missed, is inconsistent with journal information or considers only one possible answer to question*	*Straightforward application noted, simplest answer preferred; minor omissions*	*Two or more applications considered, applications consistent with journal information, applications presented are thorough and make sense*	*In depth with clear consideration of alternative approach; applications are not only consistent with journal material but often are unique*
Analysis	correlate the articles with current lecture material and prior knowledge (elaborate).	*Either no links are made or links are inconsistent with either journal or class material*	*Obvious, concurrent links are made; minor omissions and links may be incomplete*	*Connections are evident and clear; these links are consistent with journals content and class material*	*Detailed connections made, these connections are substantiated, consistent, clear, cohesive but also often creative*
Synthesis	speculate industrial/societal/scientific/ethical applications and implications of the journal content.	*Forethought either completely lacking or narrow-cited approach precludes speculation*	*Speculation present but oversimplified, abbreviated*	*Speculation is thorough and well-supported*	*Speculation is not only thorough and substantiated but may be complex and unique*

Rubric modified using the criteria suggested by the rubric for the Holistic Assessment of Critical Thinking across the Curriculum

How will students know they are learning? How will students ensure an active role in their learning?.

Because I wanted assessment to be generative in nature, I decided that rather than filling out this rubric for the students, I wanted the students to use the rubric to assess their own efforts. In doing this, it was my hope that the learners would become aware of their processes of "learning to learn" (Smith & Ragan, 2005, p. 145). I allowed the students to self-assess with the freedom to note areas of weakness and return to discussions in order to attempt to improve their contribution.

Writing Objective

A sample of a summary collaboratively written by the More Micro group is included in Appendix 4. These summaries were assessed by four non-expert readers. The first reader was an assistant professor in the Counseling department at the University. She is in her thirties with no substantial science background. Our second reader works at the front desk of East West Resorts in Beaver Creek Colorado. She has an Associates degree in a non-science field. She is in her early sixties. Our third reader was an Instructional Designer for Outreach Credit Programs at the University of Wyoming. She has her Doctoral and Masters degrees in Instructional Design. She also has a BS in Biology. She is in her thirties. Finally our fourth reviewer was an elementary school art teacher at Spring Creek Elementary School in Laramie, Wyoming. She has two Bachelor's degrees, one in Art and one in Art Education. She is in her twenties. In order to garner feedback from these readers, a survey was developed that included a bipolar adjective scale assessment item and an open-ended question asking for input. Survey development was

assisted by referencing the text, *Introduction to Research* by Ary et al. (2006). Following is the survey as it was sent to readers:

Check the appropriate box that reflects your attitude regarding the writing of the article:

Confusing								enlightening
Clear								nebulous
Unsatisfying								Enjoyable
Informative								Unilluminating
Unintelligable								Understandable
Verbose								Concise
Appropriate								Unfitting
Thorough								Incomplete

What suggestions can you give us to make our writing better?

After receiving feedback from readers, I summarized the data from the bipolar adjective scale and compiled the comments. I then e-mailed both an Excel document and a Word document to the learners so that they could then also evaluate their feedback. Please see appendix 3 for an example.

Evaluation Objective

To assess this last objective, a focus group is planned. During this group interview, learners will be asked to reflect on their experiences in More Micro. The last pertinent questions

from the PIE model will be posed to the learners: *Did students feel that they accomplished their learning objectives? Were students satisfied with the role that they played in forming and guiding learning objectives? Did students feel that instruction was personalized to them? Did students feel that their background was acknowledged (cultural / knowledge of subject material / talent)? Did learners feel that technology enhanced their learning / feelings of engagement? Did they feel it gave them an individual forum for expression as well as a social forum for learning?*

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