Gaining Instructional Design Expertise through Self-Designing, Using, and Evaluating a Performance Support System

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ABSTRACT

Gaining Instructional Design Expertise through Self-Designing, Using, and Evaluating a Performance Support System

Fengbin Zhao

In order to gain instructional design (ID) expertise, the author self-designs and uses an instructional design performance support system (IDPSS). The recursive, dynamical, and systematic process of designing, using, and evaluating the IDPSS has effectively engaged the author in learning ID knowledge and skills.

Three tools are designed and used: the consilience of learning theory tool, the ID competency tool, and the design-based research (DBR) tool. The media format includes not only computer software, such as Excel and OneNote, but also traditional pen and paper. The author evaluates and synthesizes relevant ID knowledge, and creates specific models guiding her practice. She tries to create her own instructional theory model through systematically drawing useful implications from various learning theories. This learning process is characterized by five modes of thinking: enactive, iconic, story-telling, mathematical-thinking, and formal academic writing. The author self-reflects on her learning experience by discussing a few misconceptions she has encountered, and how she has tried to correct the misconceptions.

The author designs a framework for her proposed approach to gain ID expertise, and hopes that it can be applicable to other instructional designers. Two other instructional designers have tried this approach in a small scope, and have contributed

to building the framework. As the current project tries to initiate a DBR project, a real DBR project will rely on the efforts of many instructional designers who can try this approach over a long period of time. The author discusses the potential for creating a standard DBR documenting instrument.

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Introduction

The Research Problem

Instructional designers, whether working as human performance technologists or as educational technologists, need professional growth throughout their whole career. In other words, they can benefit from a flexible human performance technology (HPT) solution for supporting gains in their own expertise. When designing HPT for others, instructional designers' goal needs to be explicit and their efforts should be systematic; however, for one's own learning, there is a tendency to carry on in an ad-hoc manner without actually systematically utilizing instructional design principles.

Moreover, ideally, each and every individual designer's gains in expertise should be aligned with the growth of competence of the whole ID community: individual designers' practice contributes to the accumulation of knowledge in ID community; and reciprocally, the advances of the ID community afford better tools to the individual designers. How can these two needs be met? That is the general problem.

The Sample

The sample drawn is the author, an instructional designer who has eight years of work experience and three years of formal education in the Master's program in educational technology. Two other instructional designers, as external learners, have tried the same approach, to a partial degree, and on a small scale with the assistance from the author. An expert has audited this project to help ensure the rigor.

Project Goal

The author aims to self-design an HPT solution for herself, which is informed systematically by learning theory and other relevant instructional design theory. Moreover, the author tries to scaffold two external learners to learn in the same approach, on a small scale, and to a partial degree.

The project will produce a whole set of HPT solution components.

1. This Instructional Design Performance Support System (IDPSS) will involve three fundamental aspects of knowledge and skills in instructional design: learning theories, instructional design per se, and a design-based research method.
2. What is offered here is a self-reflection case by the author, through which other designers might detect shared concerns, and see how the author has understood and tackled those concerns.
3. This project will provide a framework for the proposed approach to gain ID expertise, which is built with inputs from both the author and two external learners. This framework is a process that other instructional designers can follow when developing ID expertise.

Research Methodology

The project adopts design-based research orientation, here applied only in the initiation phase of a potentially indefinitely ongoing undertaking by the author. One situation is studied on a large scale: one instructional designer, the author, in one

context during a development period of a few months. As the author builds the approach from scratch, two external learners try the approach based on what the author has explored. Although, external learners try this approach partially and on a small scale, their efforts contribute to the design of the framework for the proposed approach.

Chapter One: IDPSS

The IDPSS is the artifact that I (the author) built, an important outcome of the project. Since the IDPSS is ready at the moment of writing the final report, it is utilized in assisting this writing task. The focus of this chapter is to introduce its features and potential uses, and in later chapters, the emphasis is on why and how it has been built.

A narrative can be used to illustrate why I introduce the tool before discussing how and why it has been built: a tool-inventor introduces a tool by demonstrating its features. Then, she tells the whole story of building this tool, with her analysis assisted by this tool. As a result, the audience not only knows the principles and process of building this tool, but also understands how this tool can be used through the inventor's story of how she has used it.

The IDPSS consists of three important tools: the consilience tool, the ID tool, and the DBR tool. One of the justifications for the content choice is to relate it to the required courses by Educational Technology (ETEC) program at Concordia University. Other detailed justifications of the content choice will be discussed in the chapter on instructional design.

The subject content of these tools can be linked to three required courses in the ways as illustrated in Table 1. This linking guarantees the content choice validity at macro curriculum level.

Table 1: ***Relating Content Choice to the Required Courses in ETEC Program***

IDSPP suite components	**Related required courses in ETEC program at Concordia University**
Consilience tool, founded mainly on Driscoll's(2005) textbook	Learning theory
ID tool, based mainly on IBSTPI ID Competency (Richey et al., 2003)	Human performance technology
DBR tool, based on a few journal articles on DBR	Fundamental methods of inquiry in educational technology

The common features of all tools will be presented first, and then each tool will be discussed briefly.

Common Features of Three Tools

In this part, the common features of three tools are presented.

The media format includes:

1. Traditional Paper: textbook, journal articles, and notebooks etc
2. Digitalized Files: books and journal articles in PDF format, files produced by Microsoft Excel, Word, and OneNote etc.

The IDPSS supports multiple modes of thinking, and they are:

1. Enactive mode: to benchmark procedures with checklists.
2. Iconic mode: to produce and analyze visualization graphics, such as concept maps, Microsoft's smart art graphics, and flow charts etc.
3. Symbolic mode includes:
    - Academic writing: to write formally like in a journal article
    - Story writing: to write real or imagined stories
    - Mathematical thinking: to define and operate semi-structured functions

The Consilience Tool

The term of "consilience" is drawn from Wilson's (1998) book *Consilience: the unity of knowledge*. In the context of this project, consilience represents the synthesis of learning theories. This tool can assist me in analyzing a learning situation through systematically examining some highly relevant learning theories.

Why a Consilience Tool

Driscoll (2005) adopted Reigeluth's definition of instructional theory: "identifying methods that will best provide the conditions under which learning goals will most likely be attained"(p.352). By contrast, a learning theory explains the relationship between specific learning conditions and desired learning goals.

In order to inform practice, teachers or instructional designers may either adopt design principles from instructional theories or draw implications from learning theories. Driscoll deplored the fact that few comprehensive instructional theories

exist, and that practitioners have to rely more on drawing implications from learning theories than following a good ID theory.

If there were an ideal instructional system theory that is comprehensive enough, teachers and designers' work would become less difficult and complex, and the quality of education would be improved. Unfortunately, there is not yet an ideal instructional theory. Gagne's instructional theory is a fairly comprehensive one (Driscoll, 2005), but his theory fails to consider some perspectives, such as that of social constructivism. Therefore, we have to rely more on drawing implications from various learning theories.

Each learning theory illuminates some aspects of learning while obscuring others. So, fully understanding of learning requires a synthesis of learning theories. This is a difficult, yet very important task. I design the consilience tool for the above reason. I am expecting that my instructional design practice can be informed by a complete model in a more systematic way.

What is the content?

The content of the consilience tool consists of two parts: content sources, and work files. Content sources for the consilience tool include: (a) Textbook: *Psychology of learning for instruction* by Driscoll (2005); (b) Journal articles on issues of learning; and (c) Books: *The culture of education* by Bruner (1996); *Consilience* by Wilson (1998). The work files produced based on Driscoll's textbook include Excel files, such as the consilience map; OneNote files; and Word files

What are the key functions?

The key function of using such a tool is to do learning analysis through the following processes:

1. Identifying the synthesis of learning outcomes.
2. Determining an optimal combination of learning conditions: (a) to make decision based on the synthesis of learning outcomes, (b) to link to all relevant learning theories through the theory matrix
3. Determining instructional strategies: (a) Start from the optimal combination of learning conditions; (b) For each condition, can I deductively draw new implications beyond what is mentioned in the textbook? (c) Determine the strengths and weaknesses of available experimental tested implications (prescriptive instructional strategies); (d) Decide whether the strategies can be modified by introducing new elements or modifying existing elements; (e) Determine whether all the strategies can be integrated together without any conflicts; (f) Examine again whether all learning conditions are likely to be satisfied by adopting these strategies; and (g) If any condition is omitted, work on this condition by repeating the above steps.

Its use for solving problems will be illustrated in later analysis.

The ID Tool

A complete name for this tool might be “instructional design competency tool”. This tool aims to scaffold my instructional design activities through addressing the following questions:

1. What are important skills and knowledge for an instructional designer?
2. What is my strength and weakness? How can I improve myself, on what aspects?
3. How do I evaluate some ID competency sets, such as the IBSTPI ID standard 2000 version?
4. When conducting an instructional design activity, what are the key procedures that I need to follow?

The difference between the ID tool and the consilience tool is: the consilience tool focuses on how learning theory can inform ID activity; by contrast, the ID tool focuses on a broader scope of knowledge and skills required when doing an instructional design job.

What is the content?

The content sources include: (a) the book *Instructional design competencies: the standards* (Richey et al., 2001), and (b) The textbook *Instructional Design* by Smith & Ragan (2005). Work files facilitating my problem solving include OneNote files, and Excel files.

What are the key functions?

The key functions include: (a) benchmarking instructional design activities, (b) self-evaluating of ID expertise, and (c) assisting in making career advance plan.

The DBR Tool

As the consilience tool addresses the aspects of learning theory and the ID tool addresses the whole scope of instructional design activity, this design-based research (DBR) tool focuses on the research role. DBR, as a research method, has gained researcher's attention in addressing educational research problems, which are educational researches often fail to inform practice closely（Design-Based Research Collective, 2003; Wang & Hannafin, 2005）. The goal of this tool is not only to help me understand about this newly emergent theory, but also to help me adopt a view of integrating DBR into daily instructional design practice.

What is the content?

Content sources include a few journal articles on DBR, and the textbook *Educational research: planning, conducting, and evaluating quantitative and qualitative research* by Creswell (2004). And work files include Excel files and OneNote files.

What are the key functions?

The key functions include (a) exploring DBR for the research method per se; (b) discovering how adopting the view of DBR can prompt individual instructional

designer's professional growth, and the whole ID community's advance; and (c) benchmarking projects adopting DBR as the research method.

In this chapter, I have briefly described the structure of the IDPSS, so that the audience can understand the use of this system in my writing of the final report. In the next chapter, I will make more detailed analysis of why and how I have designed these tools.

Chapter Two: Instructional Design

In this chapter, I discuss the project from the perspective of instructional design. I do not address the external learner in this chapter, and leave it to the chapter of Design-based research.

In order to determine the key components covered in writing this chapter on instructional design, I benchmark my writing with the ID tool. From the ID competency, I refer to competency groups of 2, 3 and 4 (Richey et al., 2001) to synthesize key discussion parts.

I need to make a special note here: except I mark the reference explicitly, all my following analysis is based on Driscoll's (2005) textbook, in other words, all relevant theories (including behaviorism, CIP, active reception learning theory, scheme theory, situated cognition theory, Bruner's theory, Vygotsky's theory, ARCS motivation model, Gagne's theory, and Constructivism) are referred from her book.

Design and Development Model

According to the ID Competency 13, instructional designers should know how to "select, modify, or create a design and development model appropriate for a given project"(Richey et al., 2001, p.51). My knowledge and experience of using various instructional design models are limited. However, I don't feel that learning to use various models would be difficult provided that I understand well the key design components that constitute any design models.

Novice designers might have trouble in selecting and modifying design and development models in authentic practice if they have not been taught explicitly to apply and modify models according to the constraints of projects. As most graduate students in my program, I am most familiar with the traditional design model with linear process of needs analysis, design and development, and then implementation and evaluation.

At the start phase of this project, I tried to guide my design by using this model; however, as the project evolves, my design activities resemble more of the prototype design model, in which analysis, design, and evaluation intertwine together, and continuously recur. There might be a few reasons for this: first, I self-design human performance technology solution for myself, then during the process of design, development, and implementation, my knowledge and skills have continuously evolved, so my vision of the needs has kept on evolving too. My interaction with my supervisor,

other professors, and peers has caused the change too. Moreover, the comparatively open project deadline affords the continuous change.

Therefore, although the final report presents needs analysis; design, development, and implementation; and evaluation in a linear way. The actual design activities are conducted in a non-linear, recursive way.

Needs Analysis

In this part, I discuss the learner and the learning context, the desired and the actual performance, and the possible cause and the proposed solution.

The Learner and the Learning Context

As learner characteristics of the whole target population (all instructional designers) vary greatly, I do not address learner characteristics in terms of the whole population. Instead, I focus on one learner: myself. This is similar to action-based research, or auto-case-study. The analysis on my own learning activities is detailed and in-depth. Although I do not address other learners, the analysis on my own practice might address some problems shared by other learners in our community. Therefore, in this sense, the current project carries the characteristics of conducting a qualitative research. I will address two external learners in the chapter of DBR.

When addressing my characteristics as a learner, I briefly discuss the following aspects:

1. For instructional design, I have three years of full time work experience in China, five years of part time work experience in Canada, and three years of formal

education in master program. Before accepting formal training, my practice was mainly based on my intuitive knowledge about learning. Moreover, I have a multiple-discipline background by holding one bachelor degree in accounting and another one in mathematics.

2. I hold strong passion towards this career, so I am eager to gain professional expertise. My self-regulation is good, but not great.

3. I strive to be creative and reflective, and to think critically; however, I need to improve on these aspects greatly. I am problem-solving oriented, and often take challenges as opportunities for living better.

4. I love watching movies and some TV programs, which helps me improve my imagination and creativity.

In the performance analysis part, I will conduct detailed analysis in terms of my prior ID knowledge.

As for the learning context, currently, I am at the critical period of intensively reflecting on what has been learned and experienced, refining my knowledge and skills, and preparing for normally entering the full-time work fields in Canada. The current social environment that demands life-long learning provides great opportunities for instructional designers. If we can do a great job, many people will benefit from our work.

The Desired and the Actual Performance

As I mentioned before, I adopt the prototype design model, so my needs analysis at the entry point is different from what I report here. The previous analysis is less systematic compared to the current one, but the general goal of gaining ID expertise has not changed. The current analysis is based on my self-reflection and self-assessment, and I try my best to be precise and objective.

From the consilience tool, I draw my desired performance goal in terms of general learning outcomes:

1. I should be able to remember and understand ID knowledge.
2. I should be able to use tools and concepts in ID community, and contribute to the advances of ID community.
3. I should achieve high meta-cognition, such as being able to think critically and self-regulate effectively.

Moreover, from the ID tool, I draw key ID knowledge and skills: (a) learning and other relevant ID theories; (b) research skills; (c) communication; (d) ethic and legal issues; (e) business knowledge and skills, including project management and marketing; and (f) technology application knowledge and skills. For long-term goal, I need to improve my knowledge and skills in all above aspects; within the scope of this project, I focus on the first two aspects: learning and other relevant ID theories, and research skills.

According to the desired performance goals, my actual performance can be evaluated and summarized in the following ways: (a) I can remember and understand some ID knowledge, but to an inadequate degree; (b) correspondingly, my ability of solving ID problems and contributing to ID community is limited; and (c) my self-regulation and critical thinking need to be improved.

The Possible Cause and the Proposed Solution

The analysis of possible cause is to figure out why learning conditions are not satisfied, so that my desired learning outcomes have not been achieved.

Why haven't my desired learning outcomes been achieved?

First, why can't I remember and understand ID knowledge? Based on the consilience map, I choose three theories to explain why I haven't remembered and understood well.

1. According to cognitive information processing theory (CIP), I might not attend information and recognize patterns effectively due to my limited long-term memory, and I might not encode information well enough, so that I fail to remember and understand ID knowledge.
2. Informed by active reception learning theory, I might fail to activate my prior knowledge, or the learning material has not been presented in a way meaningful to me, so that the incoming information cannot be attached to my mental models effectively.

3. According to CIP and scheme theory, the learning material might overload my working memory, or I might not use thought-demanding activities to modify or reconstruct my mental models.

Second, why can't I use the concept and tools of ID community effectively, not mentioning contributing to ID community? According to situated cognition theory, I might not participate in ID practice enough. According to Vygotsky's theory, I might not obtain appropriate scaffolding. According to Bruner, I might not engage in discovery learning. According to constructivism, I might not solve enough ill-structured problems.

Third, why can't I achieve high cognitive strategies or meta-cognition? According to CIP, I might not explicitly examine how I can improve my capacity of processing information. According to constructivism, I might not be aware of my thinking, and challenge my assumptions. According to Bruner, I might not engage in discovery learning for training my thinking.

Finally, why can't I be self-regulated enough? According to the ARCS model, I might not obtain and maintain attention effectively, or fail to see the relevance and be confident enough. According to behaviorism, I might not reinforce my self-regulated behavior enough, or I might not set appropriate goals for myself.

What are the interactions between these learning goals and conditions?

According to Ausubel, active reception learning should be the main approach in learning a subject; however, Bruner proposes that in order to learn to think, learners

should engage more in discovery learning. Do these two theories really conflict with each other? If I accept each theory in its original, intact format, they might do. But, If I draw useful implications from two theories, it is possible to integrate the drawn implications together.

For example, my goal for learning is not only remembering and understanding, but also applying the knowledge to solve problems, so I need learn to think. Discovery learning might train my thinking and problem solving skills more effectively. However, as Bruner mentioned that the precondition for discovery learning is: the learner has the prior knowledge. In other words, without appropriate prior knowledge, there will not be the basis on which the learner can discover.

Then, can I obtain prior knowledge in active reception learning? With active reception learning, I might be able to remember and understand knowledge in a fast way. However, the situation might be: at most, I can remember and understand in a short period of time; without striving to think for myself and use the knowledge to solve authentic problems, I might forget the knowledge soon.

Therefore, both active reception learning and discovery learning should play an important role in my learning. And the combination of two theories should be in comparatively small scopes of time period: at least within a term, if not within a 2-hour course. Two theories should come to play in a spiral, alternative way. Referring to outcomes, thinking and solving problems should be accompanied by remembering and understanding in one cycle of the spiral, and often in an

intertwined way. The lack of any component in a spiral cycle will obstruct the development of next spiral cycle. And the definition of each cycle could be in terms of day, week, month, or year; in terms of learning each chapter, or the whole book; in terms of one course, or the whole program; or in all above categories of scopes.

When considering self-regulation and motivation, this is the factor that can drive all above outcomes. Since I have some prior ID knowledge, the possible path is: to find a motivated problem-solving goal, to read and remember more intentionally, to solve the problem more systematically and creatively, to think more critically, to enhance confidence and satisfaction, then new needs for problem-solving emerge and new cycle starts.

To propose a solution

Based on the above analysis, I propose to gain expertise through the recursive processes of designing, using, and evaluating an IDPSS. Since I could gain ID expertise through this approach, I am highly motivated in the first place. Then in order to design this system, I need to identify ID knowledge in a systematic way, which affords that I can learn systematically. The process of designing and using this system is a problem solving process, which can engage me in discovery learning. My top-level goal of contributing to ID community and thinking critically can drive me to engage in mindful-learning activities. Therefore, this approach is potentially effective in helping me gain ID expertise.

Design, Development, and Implementation

According to the IBSTPI ID competence standard, design and development are grouped together, and implementation and management are grouped together (Richey et al., 2001). This might reflect the fact that design and development are often independent from implementation. However, in the current project, I am the designer and learner: I am learning through the recursive processes of designing, developing and implementing of a performance system; therefore, these three processes are actually interwoven. So in this part, I will discuss the aspects of content, media, strategies, and material, with design, development, and implementation implicitly interspersed inside discussing of each part. In other words, I will not discuss these three phases explicitly.

Although the discussion here is the most-updated version in the whole recursive processes, I will address how I have evolved my ideas. The change can be understood as the adjustments based on my informal, continuously, formative evaluation. I will discuss evaluation and management in the next part.

Content

Through benchmarking with the ID tool, I understand that I need to determine what content is needed for prompting professional growth; to synthesize and validate content; and to determine the appropriate breadth and depth of content according to my needs and time constraints. As I mentioned in the analysis of desired performance, I focus on learning and other ID relevant theories, and research skills.

First of all, as what I did in the chapter of IDPSS, the required courses in the ETEC program at Concordia University can justify the content choice at macro curriculum level (see Chapter IDPSS). Second, my goal is to gain ID expertise, so the ID competency standard should inform me well on content choice: I relate part of the foundation expertise in Group 1 of IBSTPI ID competency standard to the content choice by using the three tools (see Table 2 for detailed analysis).

Finally, the analysis through comparing the key words in *theory of instruction*, *instructional design*, and *design-based research* helps verify the content choice (see Figure 1 for detailed analysis).

Figure 1*: The Key Words Overlapping between Theory of Instruction, Instructional Design, and Design-Based Research.*

Theory of instruction is the major, distinctive theory guiding instructional design; instructional design lays the backdrop on which design-based research can be carried out; the ultimate goal of design-based research is to improve theory of instruction and instructional design practice.

Table 2: ***Relating the ID Tool to the Consilience and DBR Tool***

The ID Tool (Part of the Foundational Expertise)	**Relate to**	
	The Consilience Tool (Learning Theory)	**The DBR Tool** (Design-Based Research)
Application of research and theory	Learning theory is the core theory for instructional design	DBR can advance research and theory, and inform this application more directly
Updating and improving one's skills	Designers often use learning theories in design for others, what about for themselves?	Taking DBR as the driven goal can prompt the updating of one's skills
Using research skills(mainly mean used in needs assessment etc)	N/A	Practice of research skills in different contexts can reinforce the skills

Media

According to the ID competency, I need to choose media based on how technology can enhance motivation, visualization, and interaction. Besides these factors, the technology should be easy to learn and use; be effective and flexible in recording,

organizing, storing, and retrieving information; be capable of helping me analyze, visualize and express ideas in multiple-modes. Considering the above factors, I decide to choose both computer software and traditional pen and paper as the media of the IDPSS.

Sometimes, for me, the traditional pen and paper media might be more natural than computer software. I prefer reading books printed on paper than on screen. I write and draw freely on paper without worrying about technique obstacles, so I can totally focus on thinking. However, computer software can support information recording, organizing, storing and retrieving in a more efficient way than traditional pen and paper can. As for the capability of supporting interaction and visualization, computer software is superior to pen and paper.

A principle guiding my media choice is: I would not use a tool because it is new or fascinating; instead, I would use a tool because it can assist my thinking and problem-solving that other tools are incapable of. When facing the choice between tools offering similar functions, I might choose the one that is most comfortable to use. Moreover, cost is a factor constraining my choice. For example, if I can afford to have a Tablet-PC, I might use the Tablet-PC replace pen and paper somehow.

When choosing computer software, online software might promote collaboration. However, offline software, such as Microsoft Office 2007(Note, Microsoft Office 2007 also offers some online functions, but I mainly refer to its offline functions), is much better in promoting other functions. Within the scope of this project, I am most

concerned with organizing, analyzing, visualizing, and presenting information in an effective and efficient way, so I feel that Microsoft Office 2007 can meet my needs in a faster and more flexible way than most online software. Beyond the scope of this project, I might transfer the system to an online environment by using hypermedia and online-database, with Office files as important complementary components. By then, my goal would be providing the tool to instructional designers more than myself, and inviting other designers to co-build this IDPSS.

For Microsoft Office 2007, I focus on Word, Excel, and OneNote, which can meet my various needs. OneNote is most convenient in recording and organizing information, just as the name suggests. At the original phase of reading an article, searching information online, or brainstorming, OneNote might be an ideal choice.

Once material have been accumulated and understood to certain degree, and ideas have been formed somehow, Word and Excel might be the choice for further analyzing and presenting ideas. When I need unlimited space for analysis, an Excel file which provides multiple sheets and unlimited space on each sheet, is superior to a Word file which has limited space on each page. Through Excel files, ideas can be organized, analyzed, and presented in a more flexible and visualized way. However, Word is superior to Excel in terms of its stronger editing function, and sometimes, linear, natural fluent writing had better to be done in a Word file.

Both Excel and Word provide strong graphic drawing functions, and my favorite function is SmartArt. My iconic representation becomes easier and better with the assistance of SmartArt.

All three tools are potentially good project management tools. However, the multiple level structures of OneNote files and the unique tag function make me feel that OneNote would be a better choice.

Instructional Strategies

Based on the analysis of learning outcomes and conditions, I can determine instructional strategies. The top level strategy is: to gain ID expertise through the recursive processes of designing, using, and evaluating an IDPSS.

Motivation, self-regulation, situated cognition, and learning to think.

This approach can engage me effectively according to the model of ARCS: the level of attention and relevance is high; the more I work on this project, the higher my confidence might become due to my improved performance, and then I would be more satisfied because of what I have achieved.

Designing and using the IDPSS is situated in authentic contexts, so I would be learning in lived practice. During the process, I would increase my interpretation of the ID sign system, so that I can better use ID concepts and tools, and potentially contribute to the advance of our community. My interaction with the mediated tools (such as textbooks and journal articles on ID, or my designed tool), peers, and experts in our field ensures the process.

In order to design this system, I have to identify, evaluate, and synthesize ID knowledge. In order to ensure the quality of the chosen content, I start from the comparatively authoritative sources, such as Driscoll's awarded textbook on learning theory, the most commonly used IBSTPI ID competency, and other textbooks and journal articles. This identification is done either by myself, or assisted by experts (my supervisor and other professors).

With identifying content from authority sources, there is a higher chance for my accessing content with good quality. However, it is eventually up to me to evaluate and synthesize knowledge in my specific way. In other words, I need to think critically for myself; if I passively read and remember, I would become a living library without true capability of solving problems. Therefore, discovery learning would play a key role, and this discovery learning should be based on, and intertwined with active reception learning.

I would need to explore varied cases systematically, set up my hypothesis, test it, and then refine it. For a given article, I also need to figure out the author's hypothesis. Being aware of the assumption, I am open to other assumptions, so I would be free to try something different. Through this way, I would enhance my critical thinking and creativeness.

Understanding and remembering

As what Bruner suggested, the precondition for discovery learning is that the learner has the prior knowledge: the learner is discovering on the basis of what he/she already

knows. Then what would be, and how could I improve my prior knowledge? If I have systematically identified the ID knowledge, I would have a chance to know them.

However, access to the ID knowledge cannot guarantee that I understand and remember them. According to active reception theory, I would need to attach new ideas in effective ways to my cognitive structure to make this cognitive structure more general and stable. Or, according to scheme theory, I would need to accrete, tune, and restructure my schemata in order to have better mental models to understand, predict, and solve problems. My cognitive structure or mental models embed my prior knowledge.

Cognitive structure and mental models can be used to describe how information are stored and organized in long-term memory. There are a few other models explaining how information can be stored in long-term memory, such as the propositional model and the constructivism model. I think that all these models might work for different persons, in different times. So currently, I am open to all possibilities, and will try to see how I can improve my memory according to various models.

Long-term memory, working memory, and sensory memory

According to cognitive information processing theory (CIP), the corresponding status of long-term memory are sensory memory and working memory. Then how would I attend sensory information, and recognize patterns? Whenever some sensory information starts the journey of entering my sensory memory, this information is

mediated by me. This information is no longer independent from me, and it becomes "mediated" sensory information.

This mediated information then might go through the place called working memory. Often, the information that enters working memory might not come from sensory memory; it might just come from inside the learner: long-term memory. I call this type of information as "interpreted information".

Both mediated information and interpreted information would be processed in working memory for different purposes, and in different ways. The above processing might change long-term memory, or not.

Back to the scheme theory or the active reception theory, the processes of changing schemata (accretion, tuning, and restructuring) and the various processes of attaching ideas are needed to at least go through working memory. Often, these processes go through sensory memory too if they are from outside sources rather than from inside the learner.

According to the above analysis, I would need to facilitate my processing (remembering and understanding) of information from three perspectives: one is from the perspective of information per se; the second one is from the perspective of my mental models; and the last one is from the perspective of how external information interacts with my mental models.

From behaviorism and constructivism

From behaviorism, I need to obtain cues from the environment to reinforce appropriate behavior. Learning goals and informative feedback are the relevant strategies here.

According to constructivism, Bruner's theory, and Gardner's theory, I need to process information in multiple modes. And according to constructivism, I need to criss-cross (Spiro et al., 1991) my activities in different times, for different purposes, through different approaches etc.

In next part, I will discuss why and how I have designed and developed the IDPSS.

The IDPSS

In chapter two, I briefly introduced the functions of the IDPSS; in this part, I will give detailed analysis on how I have designed and developed this tool.

How have I chosen to work on this thesis-equivalent project?

My original choice of this thesis-equivalent project was on teaching mathematics assisted by Computer Algebra System (CAS), such as Maple. Choosing this topic originated from my intention of relating cognitive tools to mathematics education. I read two articles on cognitive tools, one is by Jonassen & Reeves (1996), and the other one is by Salomon (1988). I devoted great efforts to understanding these two articles. Salomon's article is more difficult for me because I encountered great difficulty in understanding the concept of *internalization*. However, it is

Salomon's article that has eventually affected me more since I had to trace back to Vygotsky's concept of internalization.

On the CAS topic, I read about two dozens of journal articles, and often one author stands in an opposite position from another one. Some articles focus on the potential use of CAS, others focus on the realistic problems encountered in practice. Most of these researchers hold an assumption by accepting whatever the CAS tool is.

However, the problem is: most CAS programs were originally designed for use in professional field, which means that the person who uses the CAS software knows mathematics. When trying to use CAS in learning mathematics, the learner needs to have some prior mathematics knowledge. I realized that it would be very difficult for CAS to play the role of cognitive tools as the one proposed by Salomon. CAS simply does not provide explicit operations, which is the necessary condition for a cognitive tool candidate; therefore a learner cannot internalize the intelligence from the cognitive tool (AI in reverse). If a CAS program can be re-designed to embed explicit operations, it might be able to achieve the goal of AI in reverse.

Although I did not achieve the goal of explaining CAS-assisted mathematics education by using the concept of AI in reverse, this experience brought me to somewhere. I frequently referred back to Driscoll's textbook in order to understand various aspects of educational problems mentioned in the CAS journal articles and two cognitive tool articles. I re-interpreted my prior experience with new

understanding through re-reading the book. This rewarding experience made me realize that, whatever the subject matter is, learning theories can explain learning in similar ways; there will not be great differences for explaining a mathematics learning problem, a second language learning problem, or any other learning problems.

Therefore, I had the idea of working on a project in helping me gain instructional design expertise. The concept of "AI in reverse" and "designer as learner" inspired my choice on the approach of gaining expertise through the recursive processes of designing, using, and evaluating an instructional design performance support system.

AI in reverse.

Salomon (1988) proposed that as computer software can simulate some human intelligence (which is artificial intelligence [AI]), under certain conditions, human beings can simulate some computer embedded intelligence too. This is called AI in reverse. Salomon justified his theory by using Vygotsky's concept of Internalization. According to Vygotsky(1962), a child's language development experiences two phases: interpersonal and intrapersonal, and the transition from inter to intra is called internalization. Salomon argued that while a learner works with a computer cognitive tool, at first, it is the inter-relationship between he and the intelligence embedded in the tool, then under certain conditions, the learner might internalize the intelligence, which becomes the intra-relationship between he and the

intelligence. In other words, the learner has internalized the intelligence.

Salomon then further examined the conditions for a candidate cognitive tool: tool-like nature, relatively novel functions, compatible with the learner's prior knowledge, and most importantly, the operations should be explicit. Only when the operations are explicit, can the learner interact with the intelligence explicitly and then eventually internalize it. In order for the internalization happens, the learner need engage in mindful-learning activities.

Designer as learner.

Jonassen and Reeves (1996) defined cognitive tools as "technologies, tangible or intangible, that enhance the cognitive power of human beings during thinking, problem solving, and learning"(p.693). They made a review on the use of a series of computer software as cognitive tools, such as computer programming language, database, and expert system. An expert system refers to a computer-based tool that simulates the intelligence of human experts; therefore, when one consults this system for decision making, this system acts as an expert. One might learn through designing an expert system, which is *designer as learner*.

In order to design an expert system, a learner needs to systematically identify and classify both declarative knowledge and procedural knowledge in the field; therefore, the learner access to the knowledge of a subject intensively and systematically. Since most expert systems consist of knowledge database, inference engine, and user interface, the learner needs to figure out the operating logic of the

inference engine, which is certainly a very complex task. Designing expert systems is undoubtedly a great way of learning; however, a truly functional expert system is unbelievable complex, and difficult to design and develop. So, I decide to borrow some elements from expert systems, such as the systematical content and figuring out some operating logic.

The orientation towards systematic content could help me learn ID relevant concepts and tools as systematically as possible; I try to extend the possibility of "engaging in active reception learning" into my after-formal-education daily practice.

How has the consilience tool been developed?

In Driscoll's (2005) classic textbook of "Psychology of learning for instruction", she presented and discussed a series of learning theories in excellent ways. She claimed that learning theories are not the truth of learning; instead, they are only visualization models to make sense of the available data. She emphasized that each learning theory illuminates some aspects of learning while obscuring the others. Therefore, no single current available learning theory is a complete model for explaining learning; instead, each theory is an incomplete model, and a series of models (we might have only found a few models) are needed to fully explain learning. In the last chapter of the book, she proposed that each designer or teacher construct his/her own learning theory.

Although I had kept on reading Driscoll's book for a few years, I did not get her

point. I had always assumed that constructivism is the best learning theory; therefore, for each project I worked, constructivism became the solely justification for my works although I might have not truly understood constructivism. To my impression, constructivism is the word appeared most frequently in journals, so my logic was that the most frequently discussed theory should be the best.

However, a few cognitive conflicts made me investigate further on constructivism. The first cognitive conflict was: I felt that I had not truly understood constructivism. The second cognitive conflict was: I was confused on the debate of "Why minimal guidance will not work". The third conflict was: I encountered the difficulty of using constructivism to justify learning mathematics with the aid of CAS. These conflicts prompted me to re-read Driscoll's book time after time, and re-relate these theories to my prior experience. Finally, I could truly understand Driscoll's presentations.

Since constructivism mostly stays at the phase of theoretical conjecture, it remains open to tell its capability of explaining and prescribing learning. As for now, constructivism at least fails to identify the process of learning except the construction and reconstruction. Moreover, due to its high requirement of time and resource, the educational reality of limited resources makes its practice extremely difficult. Nevertheless, I agreed with Driscoll's comments: as information technology advances, constructivism becomes more and more affordable.

Then at the point of starting the project, I decided that whenever I need to

analyze a design practice by using learning theories, I would adopt a systematical way of comparing the affordance and constraints of various theories, and then tailor the synthesis to the given context. The frequent use of learning theory in my project is similar to call a function repeatedly. Each time the function is called, the input variables change their value; therefore, the application changes too. Each time I apply learning theory, I am accumulating data for my efforts towards consilience.

How has the ID tool been developed?

I knew about the IBSTPI ID competency standard (Richey et al., 2001) from the instructional design textbook (Smith & Ragan, 2005). When I first saw it from the official IBSTPI website (www.ibstpi.org), there were only competency statements. I did not understand well these statements. Later, from ERIC, I got the book demonstrating this competency standard. Then I felt that it is possible to build an ID competency tool to benchmark my ID activity.

If I define that each time of reading is a turn of interaction, I might have interacted with Driscoll's textbook for a few hundred times, and with the book on IBSTPI ID competency standard for dozens of times.

Originally, I embedded the competency and performance statements to Excel files and OneNote files, and hoped to use it to benchmark my instructional design activity. However, for some of the competency, I did not understand well. In order to evaluate and use this tool, I had to refer back to the book for understanding. As I

understand better on learning theories, my understanding of this set of competency has improved too.

For the instructional design textbook, I did not read all chapters carefully, not mentioning other books on instructional design. I was required to take exams on both the research method course and learning theory course, so at least, I read those two textbooks. For the HPT course, I was not self-regulated enough to read. Even though, the course outline listed the required readings for each week, I simply failed to do so. This phenomenon happened to me in other courses too. My reading was mainly guided by my felt needs for solving a project problem or taking an exam. However, without systematical reading, I often failed to identify needs.

Therefore, when setting up the goal of designing a performance support system, systematically identifying ID knowledge is the sub-goal. This goal has driven my reading.

Within the scope of this project, I develop the ID tool mainly based on the competency standard; beyond this thesis project, I need to read a lot more, and integrate more. Fortunately, my current understanding of learning theories are good, so my reading of instructional design articles should be much faster than a few years ago.

How has the DBR tool been developed?

After reviewing my first draft proposal, my supervisor suggested that I should take design-based research as my rationale, and he sent me the article on DBR by

Wang & Hannafin (2005), and the website (Instructional Technology Ph.D Students at the University of Georgia, 2006). When first reading Wang & Hannafin's article, I seemed to understand some key words used to describe DBR, such as the complicated, dynamical, recursive processes. However, I found it difficult to understand some of the illustrations. So, I transferred to the website. The website is intended to teach and promote DBR, so the writing is comparatively easy to understand. I tried to summarize the key points and then produced a benchmarking document for relating my project to DBR. This worked pretty well, so I formed my original scheme of DBR.

My efforts towards understanding DBR then stopped until my supervisor sent me another DBR article by Design-Based Research Collective (2003). Working on the SPF assisted by my supervisor also made me realize that I need to know more about this research method. I briefly reviewed the article by Design-Based Research Collective (DBRC), and I seemed to have no much impression on it. I then re-read Wang & Hannafin's article, it was better than previous time, but I still felt difficult. So I tried an approach by transforming the article's content to some graphics, hoping that the process of producing iconic representations can assist my understanding. This strategy worked somehow, but I was still unsatisfied with my understanding. I thought that I might need to read some works cited by Wang & Hannafin, so I found some of the cited journal articles by this article.

However, I only briefly reviewed the two most original articles, one is by Brown (1992), and the other one is by Collins (1992), and I did not have much impression on these two articles. At the same time, I was reading *the culture of education* (Bruner, 1996). I became extremely sensitive to social factors. Then one day, I picked up the DBRC article, I not only used the iconic translating/transforming approach, but also read it aloud. I was excited that I seemed to have understood this article very well, and could relate it to my project in some new ways. This article is concise and clear, so I understood not only the principles and concepts, but also the illustrated examples. However, I felt that I needed to review the research method book on quantitative, qualitative, and action-based research for clarifying a few points.

The above experience made me realize that I might need to incorporate a research tool to the IDPSS. This research tool will not only help me think and solve problem like a researcher, but also provide an analysis platform for relating design-based research to other tools of the IDPSS, such as linking to the consilience tool by creating a documenting tool for DBR, and linking to the ID tool for exploring ideal ID practice.

Within the scope of this project, I will mainly base on the DBRC article. Beyond this thesis-equivalent project, I will enrich it by reading and incorporating other DBR articles and research method books or articles.

How have I developed multiple modes of thinking?

As I mentioned in chapter 2, the IDPSS should support multiple modes, in this chapter, I will discuss in detail on how I have developed my scheme of utilizing multiple modes of thinking. I adopt Bruner's approach on multiple modes:

1. Enactive mode: to benchmark with checklists
2. Iconic mode: to produce and analyze visualization graphics, such as concept maps, Microsoft's Smart Art graphics, and flow charts ect.
3. Symbolic mode includes
    - Academic writing: to write formally like in a journal article
    - Story writing: to write real or imagined stories
    - Mathematical thinking: to define and operate semi-structured functions.

I agree Bruner's (1996) comments: in his earlier works, he and his colleges had been over-simplified by taking cognitive growth as the progression through enactive mode, to iconic mode, and then to symbolic mode. He modified this model by admitting that iconic mode might be more advanced, and might be used to benchmark symbolic thinking. Also for the enactive mode, he referred more to procedures.

For me, iconic and symbolic representations are often intertwined together, and my definition is: if a representation involves graphic, I will call it an iconic mode. For symbolic mode of thinking, I make further categorizing according to my current

needs and knowledge: mathematical thinking, story-telling thinking, and academic writing.

I hold one bachelor degree in mathematics and another one in accounting. I also know a little computer science knowledge, such as a few programming language, and some knowledge on data structure and database. Because mathematics is an important tool for the fields of accounting and computer science, thinking mathematically is what I have obtained from the experience.

Except some textbooks, and some psychology books, I have not read many novels or other books, but I have watched a lot of TV programs and movies. For me, this is one important way of internalization of culture, in China, or Canada. Therefore, I love the story-telling way of thinking because it can make complicated things simpler, and make abstract things more concrete. Story-telling is a natural reasoning way that I might have used a lot in my daily life.

Academic writing is the most difficult one for me. However, as I live in a world that values and reinforces academic writing, I have to train myself to adapt to it. In order to be a knowledge consumer and contributor, I have to become competent in understanding and writing academic works. An idea has bothered me for a few months: why can't academic writing be expressed in a more vivid and concrete way for engaging a more variety of audience other than those full participants of a specific field? Even though for those full participants, would not more choices be better?

If I could not have my needs met by the external world, I might need to do this for myself: to transform abstract academic writing symbolic modes to story-telling symbolic modes and iconic modes. These translating/transforming processes not only facilitate my understanding and remembering, but also prompt my analyzing, synthesizing, evaluating, and creating. Reasoning through visualized graphics or vivid stories often helps me solve problems to an unexpected degree. A good example for story-telling would be the AI in reverse one (see Appendix A). A good example for the iconic mode would be the big map of consilience (see Appendix B).

If iconic thinking and story-telling work so well for me, what is the need for mathematical thinking? An example might explain the reason. The double roles as both designer and learner often confused me, and the confusion became worse when what I am learning happens to be ID knowledge and skills. In order to get out of this confusion, I thought of a folk song: once upon a time, there was a mountain; inside the mountain, there was a temple; inside the temple, there was an old monk; and the old monk said: once upon a time, there was a mountain……" To translate my situation into this folk song, it would be in this way: there is an instructional designer; this instructional designer is designing an instruction for herself; the goal of the instruction is to help her gain the expertise of instructional design; her approach is to design a performance system for the task of instructional design…..

Through this story-reasoning, my confusion was clarified somehow, but not completely. I then told my husband about this "old monk" thinking, my husband

responded: “it is called recursive function in programming language, and it is frequently used”. I answered “Vow, you are so right, why didn’t I realize it”? Then my confusion could be totally clarified through this recursive function way.

Here is how I did it:

1. I define the function of instructional design as

   ID (for whom, by whom, what, why, how, when, other variables)

2. Then, to assign value to the variables in this ID function for my project

   - For whom=myself as the learner=the ID practitioner who needs to update ID expertise
   - by whom=myself as the instructional designer=the ID practitioner who designs an ID solution
   - what=ID expertise
   - why=to gain ID expertise
   - how= through the recursive processes of designing and using an ID performance support system

   etc

3. Everything called ID in step 2, can potentially become another ID function. Before I go to deeper levels, my attention is focused on the current level, and once I am comfortable with the current level, then I consider deeper levels. In this way, my cognitive load is decreased, my role confusion is

clarified, and I can distinguish the components that otherwise tend to entangle together.

My intention was not to define a precise function for representing the current project; instead, I used this function-defining as a way of thinking to clarify my own confusion.

Statistics is used in quantitative researches for understanding the relationship between variables. My knowledge of mathematics can help me understand and solve educational problems, in ways of meaningful to me. Thinking mathematically is similar to define a model with regularities, and to use the model benchmark my thinking and solving problems. Then I might examine, refine, and reconstruct the model according to the feedbacks.

This sounds similar to the process of attaching ideas to the cognitive structure, or the processes of accreting, tuning, and restructuring of schemata. Indeed, when trying to define a mathematical model, I am trying to identify variables and relationships. And the representations of these variables and the relationships constitute my comparatively stable cognitive structure or schemata. Without using the mathematical model, I might have the same cognitive structure or schemata; however, the difference is that I might lack the more explicit and systematic way of thinking about it.

One might argue that mathematics best represents well-structured problems, not ill-structured problems. I admit this point and define my mathematical models

as semi-structured models. For the well-structured part, I believe there are regularities that are provisionally, commonly agreed by the members of a community. For example, most educational practitioners might agree that both cognitive and social factors are important for understanding learning. The function of learning then should at least include two variables: cognitive and social. This is the well-structured part.

For the ill-structured part, there might be unknown variables and relationships, or the understanding of these variables and relationship are far from reaching consensus by the members of a community, for example, the tension between active reception learning and discovery learning might be an ill-structured component for explaining learning. Moreover, the diverse and dynamical nature of the world determines the ill-structured part too.

From my understanding, the general goal of conducting a research is to identify regularities. And this identification might experience qualitative and quantitative phases. If I take my personal learning as a research process, I should be able to borrow some elements from research methods, and to integrate these elements into my daily learning process. Posing and testing hypothesis is an important component of discovery learning and inquiry teaching; even novice researchers are expected to know something about testing hypothesis. As I extend my thoughts along this thread of thinking, I am amazed at the hints that I can get from research skills, and at the possibilities of relating these hints to learning strategies. For

example, data collection, data analysis, and graphic representation through software such as SPSS all can give me some hints. I would stop this discussion here, and I am going to explore more beyond this project.

Back to the multiple modes of thinking, I have discussed about iconic mode, story-telling symbolic mode, and mathematical thinking symbolic mode. I also briefly mentioned about academic writing symbolic mode. Now, I will discuss the enactive mode. My understanding of the enactive mode is obtained from Bruner's (1996) comment on enactive mode, which is enactive mode is more about procedures, he gave the example of what lawyers do in the courts. When conducting instructional design activities, I should conduct needs analysis, and the needs analysis should be about the learner, the environment, and the learning goal. This is the procedure that I need to follow.

Basically, I can transform everything that involves procedure to a checklist for benchmarking my actions. Therefore, the enactive mode utilized in this project refers to my benchmarking with checklists. I might either put the checklists in OneNote files, Excel files, or Word files. Moreover, often the checklists might have a hierarchy structure, such as the IBSTPI ID standard.

With adequate time, I might transform everything I have done in this project into five modes. However, I can only try in an un-systematical way due to time constraint. Beyond this thesis-scope, my goal is to build a complete five-mode IDPSS; moreover, I might integrate new modes. These five modes have prompted

my thinking in a spiral way, and I believe that systematically revisiting each mode should be the most effective way.

Moreover, the concept of criss-crossing can justify this approach too. Spiro et al. (1991) proposed that "revisiting the same material, at different times, in rearranged contexts, for different purposes, and from different conceptual perspectives is essential for attaining the goals of advanced knowledge acquisition"(p.28). My creating and using multiple modes of thinking is a way of criss-crossing by using different modes.

Evaluation and Management

In this part, I will discuss evaluation and management.

Evaluation

During the whole design and development process, I have not conducted formal formative evaluations; instead, my evaluations have been done continuously. However, there are two major modifications. So, I will address the formative evaluation by discussing these two modifications.

Modification one: from where am I internalizing knowledge?

My original idea for this project is to learn (a) through embedding intelligence to computer software, (b) through cooperating with the software to conduct instructional design activities, and (c) through internalizing some intelligence that I embedded into it.

I embedded the ID competency (Richey et al., 2001) and the comprehensive theory matrix (Driscoll, 2005) into OneNote and Excel files. However, I found out that when I tried to use the files, if I hadn't understood the lists or matrix, I had to refer to the original sources frequently. In other words, I did not internalize knowledge from my designed tools; instead, I internalized knowledge from the books. So, the IDPSS at least should include the books.

As I understood well through repeated reading, I then actually re-processed (include analyzing, evaluating, synthesizing, and creating) the knowledge, and embedded the processed information in Excel or OneNote files. The situation then changed, I can work with the aid of the IDPSS without referring back to the books. The maps, narrative stories, and checklists all assist my working. When I write this final report, the big consilience map and other relevant files often help me figure out a solution that otherwise would be difficult.

For the first few turns, I still had to open the consilience tool in the Excel files (to cooperate with the tools that I designed). After a few turns of using the tools, the map was partially in my mind. I could think when lying on my bed or walking, with the map in my mind. So, at that point, I might have internalized the intelligence from my designed tool to certain degree. As I used the tool to solve problems, I generated ideas for improving the tool. Therefore, I could truly realize what I mentioned in the Robot Story (AI in reverse, see Appendix A).

So, from this experience, I modify my definition of cognitive tools and internalization. My concept of cognitive tools has been extended to what Vygotsky and Bruner defined as cultural tools, like language and the by-products of language; it does not matter what the media containing the knowledge is: paper-books, digital files, toys, or human beings (my supervisor, other professors, and my friends). In other words, I might internalize intelligence from all the above sources. Therefore, my IDPSS should include all possible media formats, like James Bond' whole tool kits, even including his supportive team if considering human factors.

Modification two: to incorporate design-based research.

My supervisor's suggestion on incorporating design-based research to this project has brought unexpected effects from a few perspectives. First, my previous content choice focuses on learning theories and ID competency, and I did not realize the importance of research methods. I thought that I was doing an instructional design project, and I did not need to care too much about research methods. In other words, I did not think research skills are very important for helping me gain ID expertise. My implicit assumption was that research skills are for academic researchers, not too much for instructional designers.

Currently, I am able to find lots of evidence against my previous misconception. My discussion of content choice in previous parts can indicate the importance of mastering of research skills by instructional designers. Therefore, introducing DBR affects my content choice. In order to understand design-based research, I not only

read the journal articles on design-based research, but also refer back to my research method textbook (Creswell, 2004). This has brought me some new insights. For example, by integrating DBR with ID practice, I see a direction for ideal collective and individual ID practice.

Another amazing idea is: as the DBRC's article mentioned that a good documenting instrument is very important for DBR (Design-Based Research Collective, 2003), I produced the idea of linking the consilience tool to the DBR tool. DBR needs to document that how different variables and interactions can affect learning outcomes. The consilience tool is exactly aimed to consider factors relevant to learning as complete as possible. Therefore, the consilience tool might facilitate the design of a database structure for the DBR documenting instrument. I will make further analysis in the chapter of DBR on this issue.

Finally, in order to be a design-based research project, I need to involve some external learners. Being a teacher improves my own reasoning. Moreover, my goal for this project was extended to include creating a framework applicable by other instructional designers.

Summative evaluation.

For formative evaluation, I discuss the above two aspects. For summative evaluation, I self-evaluate this intervention, and conclude that this is an effective intervention. The learner's (my) goal-directed behavior, critical thinking, ability of solving ID problems, and understanding and remembering of ID knowledge have all

been improved greatly. I think that the choice of content, technology, learning strategies are appropriate for my goal. My analysis in different places of this report actually embodies my self-evaluated improvements.

My supervisor might be able to judge this from his interactions with me, from comparing my writing in the start phase of the project with my current writing, such as the proposal, the tool, and the final report.

Moreover, I can support this by stating that: (a) I can read an ID relevant journal article in a faster and more critical way than a few months ago; (b) I can figure out an instructional design solution faster, more creatively and systematically; and (c) if I debate something about ID, I can better support my opinion. This kind of proof is again mainly based on my self-reflection and self-evaluation.

In this project, assessment and evaluation are closely intertwined. Assessment might focus on the learner's changed performance, and evaluation might address the effectiveness of the intervention, in terms of content, technology, and learning strategies. Eventually, the effectiveness of this intervention might best be supported by the improvement of the learner. And since there is only one learner (me), the intervention is highly relevant to the learner.

The problem for assessment and evaluation might be the subjective factor because I am the learner, designer, and researcher. I try to address this problem from a few perspectives. First of all, the whole project is built on sound theoretical foundation, and I have tried to benchmark my efforts with synthesis of learning

theories and ID competency standards. Second, I am highly reflective during the whole project, and try my best to be objective and precise when writing this final report. Third, like in an auto-case-study or other qualitative studies, it is impossible to completely ensure objectiveness since subjective interpretation is part of the research process. Even in a well-controlled quantitative research, it is impossible to reach being objective completely so long as the research is about human behavior and performance.

The expert who reads my interpretation of my own activities can help ensure the rigor, so I invite an expert in educational research to achieve this goal. The expert has the impression that I seem to have tried to be objective. And he commented that I even can use the approach to design a learning environment for other instructional designers.

In future efforts following this project, if I am the researcher and other designers are learner- and-designers, the objectiveness might be improved due to my external observation and evaluation from start. However, the designer's self-reflection, self-evaluation, and self-interpretation all will determine the objectiveness. I will address that how my interaction with external learners can triangulate the proof for proving the effectiveness of this approach (see chapter on DBR).

Management

The special emergent and dynamical nature of this project has increased the difficulty of project management. My continuously evolved knowledge and skills determine that I often see the potential for improvements and the needs for adjustments. However, I have to stop at some point and wrap up this thesis project.

Moreover, my communication with all stakeholders can be improved. I understand that it is normal that projects might not be accomplished in time due to some adjustments, and the key is to communicate honestly, and in time with relevant stakeholders. However, I often failed to communicate in time.

Finally, effective documenting might have improved my efficiency greatly. I often had lots of ideas, which were forgotten soon if not documented well. At the starting phase of this project, I discovered the amazing documenting function of Microsoft OneNote 2007. Unfortunately, I failed to stick to using it. If I have written reflective journals every day and have documented my ideas in a structured way, I might be able to achieve a lot more than I actually achieve today.

Chapter Three: Design-Based Research

Since I am working on a thesis-equivalent project, it is necessary that I address the components of instructional design. However, going beyond being a design project, the true nature of this project is a design-based research project. In this chapter, I will address the following questions: (a) What is design-based research? (b) How do I address objectiveness, validity, and reliability? (c) What is ideal ID practice by

integrating DBR into ID? (d) What is the potential for producing a DBR documenting tool? (e) What have the external learners brought into this project? (f) What is the framework produced for other instructional designers?

About Design-Based Research

Wang & Hannafin (2005) defined design-based research as "a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real world settings, and leading to contextually-sensitive design principles and theories" (pp.6-7). Design-Based Research Collective (2003) emphasized that the "central goals of designing learning environments and developing theories or 'prototheories' of learning are intertwined"(p.5), and it is important to have a sound documenting method to link context factors, the emergent and dynamical interactions to successes and failures.

The reasons for applying the method of DBR are to ensure that educational research can inform practices directly, and to promote the application and development of learning theories. However, there might be a few challenges for conducting DBR: ensuring objectivity, ensuring reliability, ensuring validity, maintaining collaboration, and generalization of findings (Design-Based Research Collective, 2003).

Objectivity, Validity, and Reliability

I addressed about objectivity in the chapter of instructional design. In this chapter, I will discuss it more from the perspective of DBR. According to Design-Based Research Collective (2003),

> Educational interventions should be seen holistically: interventions as enacted through the interactions between materials, teachers, and learners. Because the intervention as enacted is a product of the context in which it is implemented, the intervention is the outcome (or at least an outcome) in an important sense. (p.5)

Therefore, the approaches of ensuring objectivity, validity, and reliability should be different from traditional experiment studies.

For ensuring objectivity, I have tried to maintain the dual roles of both *advocate* and *critic*. I have mainly challenged my own hypothesis through interacting with various sources and self-examining. Moreover, my documenting and interpretation is based on a systematic theory foundation, which can help ensure the objectivity. Finally, an expert in our field reading my report judges that I seem have tried to be objective in my interpretation.

My intention of being informed by the consilience of learning theories, and my gaining feedbacks from experts, such as my supervisor and other professors, can help ensure validity. Moreover, the recursive processes of design, development, and

evaluation helps increase the “alignment of theory, design, practice, and measurement over time”(Design-Based Research Collective, 2003, p.7).

Within the scope of this project, I can only address reliability by stating that my research is based on a comparatively standard instrument (my thinking and solving problems based on the synthesis of learning theories), which can help ensure the reliability within one setting (me as the learner) across a few design and enactment cycles (a few informal formative evaluations).

This project invites two instructional designers (external learners) to try the proposed approach in small scope. The purpose is not to generalize research findings: I think design-based research might experience various research phases, from with more qualitative characteristics to with more quantitative characteristics. This transition will happen as more and more data are accumulated and more and more themes are identified, both within and across settings, and over long period of time. Two external learners might expose some new themes, and examine my proposed approach from their perspectives.

The current project is only the initiation phase of a long-term design-based research project. I am conducting research, in a complete scope, in one setting (myself), and some themes might be identified from this initial phase. Due to the time constraint, external learners can only try this approach partially.

Interacting with external learners helps me have a clearer vision on my own research. My reasoning becomes more logical because of my trying to teach external

learners. From this sense, the internal validity of this project is improved. Moreover, I can create better framework for the proposed approach due to the interactions with external learners.

Ideal ID Practice

DBR emphasizes integrating design and research, which might imply that, in order to promote the advance of ID community, instructional designers should explicitly play the role of researchers.

Relating DBR to Instructional Design Practice

According to the IBSTPI ID competency (Richey et. al, 2001) instructional designers should adopt research skills while conducting needs analysis and evaluations, and base their practices on sound theories. Moreover, designers should continuously update their knowledge and skills. Formative evaluation should be a key component of ID, and it is desirable for designers to document their ID activities. Therefore, ideal long-term ID practice processes should be quite similar to design-based research processes: instructional designers carry the goals of improving ID relevant theories in their ID practices.

The major difference between DBR and ID might be: DBR is a research process with the primary goal of generating theories, and this goal dominates the whole process: short-term or long-term. By contrast, ID is a design process with the primary goal of designing solutions to a problem, no matter whether generating new theories or not. And in most situations, a single design project might be in short-term. In DBR, the *new*

theory might mean new collective ID knowledge. By contrast, in ID, for an individual instructional designer, the *new* theory might be in reference to both individual expertise and collective ID knowledge.

An ideal situation in ID community is: The processes of ID and DBR are closely intertwined, learning theories are continuously tested and refined, and practices are continuously improved. Please refer to Figure 2 for the illustration.

	1st period			**2nd period**			……..
Setting 1	ID_1	DBR_1	Practice	ID_1	DBR_1	Practice	……..
Setting 2	ID_2	DBR_2	Improved	ID_2	DBR_2	improved	
……	……	……	Theory	……	……	Theory	
Setting N	ID_n	DBR_n	Refined	ID_n	DBR_n	refined	

Figure 2*: An Ideal Collective ID Practice.*

From Figure 2, we can see that DBR is the driving goal for the advance of ID community. It is like there is a goal for a big-scale of ID project, with many participants from various settings, over a long period of time. However, as I mentioned: it is an ideal situation, not a realistic situation. The realistic situation will be constrained by many factors, which means that the ideal situation is impossible to be fully realized. The best situation that we can expect is to go towards the ideal situation as near as possible.

An ideal scenario in an instructional designer's practice and professional development: DBR is the driving goal for prompting the individual's professional growth

and contributing to the advance of ID community. Please refer to figure 3 for illustration.

	1st Period, or 1st group of design activities		**2nd Period, or 2nd group of design activities**		…….. N
Individual Activity	ID DBR	Gain expertise & contribute to ID community's development	ID DBR	Gain expertise & contribute to ID community's development	------

Figure 3*: An Ideal Individual ID Practice*

From Figure 3, we can see that in the whole career of an instructional designer, the more systematically and explicitly she/he embeds the DBR components into short-term and long-term ID practice, the faster and better she/he can gain professional growth and contribute to the growth of the whole ID community.

Therefore, any intervention that can support the integrating of DBR components into daily ID practices will be helpful in promoting ID professional growth. In other words, an intervention is likely to be effective in promoting ID professional growth if it can (a) make generating new theories (individually or collectively) a more explicit goal in daily ID practices, (b) better support systematical documenting, (c) better assist data-analysis for the reflective practice.

Hence, in this way, DBR could help justify why I propose gaining ID expertise through designing, using, and refining the IDPSS. However, I don't feel that the current project is capable of producing a DBR project in a complete sense considering its time constraint; it could only be a starting phase of a DBR project. Instead, DBR could be the long-term goal, the driven factor, and part of the theoretical foundation for the proposed approach.

A DBR Documenting Tool

Design-Based Research Collective (2003) stated that "design-based research relies on techniques used in other research paradigms, like thick descriptive datasets, systematic analysis of data with carefully defined measures, and the consensus building within the field around interpretation of data"(p.7). They emphasized that the key technique ensuring DBR is the documenting technique that can effectively link processes to outcomes by fully considering contextual factors and emergent interactions.

The consilience tool is designed for addressing full aspects of learning, so it can potentially be used for building a data-structure foundation for a DBR documenting tool. The concepts of data-warehouse and data-mining have been widely used in a few industries: financial institutions, bioinformatics research, and big-scale online enterprises, such as www.amazon.com, and www.yahoo.com. Can this concept be applied in educational research? I understand that meta-analysis might be similar to this concept to certain degree.

Meta-analysis is more about past; DBR is more about future; and meta-analysis is completely quantitative (Bernard R, personal communication, March 3, 2009). So, I think that the data structure is built when conducting a meta-analysis; however, in a DBR project, the ideal situation is that data-structure can be built at early phase of the long-term research. At least, a semi-data-structure should be built, and this structure can be continuously refined as new themes are discovered. The more themes can be identified and embedded into the data-structure and the earlier the above actions are, the more possible that useful theories can be identified through data-mining, and then practices can be improved earlier.

Another potential benefit is that DBR practitioners can benchmark their design efforts with the documenting tool. At least, they can address learning problems from a comprehensive perspective without making the mistakes of over-emphasizing one or a few theories while under-emphasizing or omitting other potential useful theories.

Hence, beyond the scope of this project, my efforts can go towards constructing a DBR documenting tool based on the consilience tool. Maybe the first context for using such a tool is my own and other instructional designers' gaining ID expertise.

External Learners

Involving external learners has changed my role from as a learner to as a teacher. As I often worried about the time constraint of this project, I was a little reluctant to invest time on external learners. In the first place, my supervisor suggested that I should invite external learners, and he insisted it when I tried to neglect this part. Now, I realize the

great benefits that I have obtained from this teaching process. My major idea for this project has been under examination when interacting with two learners. Both of them have given me great feedback and recommendation, which has stimulated my deeper thinking and efforts for refining this approach.

The Brief Description of the Learning Activities of External Learners

My original plan for external learners is: (a) to review the theories of Ausubel, scheme, and Bruner, and then critique a course. (b) to design an IDPSS for themselves by applying above theories, and (c) to re-evaluate the course with assistance of the IDPSS.

The reason of choosing these theories is: I feel that the tension between Ausubel's theory and Bruner's theory represents a typical debate in our field, which can be a good cognitive conflict for external learners. Moreover, I feel uncomfortable to put two theories in two polar positions, and have experimented my way of integrating implications drawn from both theories. I am interested in knowing other designers' opinions on this problem. Driscoll linked and compared Ausubel's theory and scheme theory by putting them in a chapter, so I just include scheme theory too.

However, I have to change my original plan on a few aspects: first, it took a much longer time for both learners to review a few theories than I had expected, with one learner three full days, and another one two nights. So, I think it would be more appropriate to call this task as part of the intervention than to call it a pre-assessment. And in order to decrease work load, I told both learners to focus on active reception learning theory and discovery learning theory.

Second, I have focused on facilitating their understanding and evaluation of the theories. I strongly believe that, without the orientation of understanding, evaluating, and applying learning theories, my proposed approach will fail. Moreover, since eventually they need to self-design and use an IDPSS, another important task is to help them understand this approach, especially to help them distinguish their role as learner from as designer, or tool collaborator (the tool is the IDPSS that they design for themselves). However, these two tasks consumed lots of time, so the time schedule fell behind. Therefore, I can only try this approach partially.

Nevertheless, I think that two learners have touched upon the two most important and difficult tasks for trying this approach. The feedback I have gotten from interacting with them can contribute to refining and enriching the proposed approach. So, my following analysis will focus on the implications that I can draw from their learning, rather than on how much progress that they have actually obtained. It requires more time for them to try this approach in a complete sense.

Both learners have read Driscoll's textbook on the assigned theories, it took Learner A 2 evenings, and Learner B 3 days. It has been a long time from their last time of reading this book: over a year ago for Learner A, and almost 3 years ago for Learner B. I had a conversation with them before their reading: I briefly summarized the key points of the theories, and intentionally mentioned that active reception learning and discovery learning might conflict with each other, and what a true act of discovery learning is according to Bruner.

Then, Learner A evaluated the research method course by applying two theories, and Learner B chose to design a course teaching composition. Learner A has a background that is very different from our field before enrolling the ETEC MA program, and she has graduated for one year; Learner B has a few years of teaching experience, and has graduated from ETEC MA program for two years. As for the prior knowledge of discovery learning, Learner B has tried this approach in her previous design project, and Learner A does not have such prior experience. Both of them wrote down their analysis.

Learner A also sent me another document for her plan of designing an IDPSS. When seeing this document, I did not see the explicit explanations on how she has applied two theories in her design. So, I did not ask Learner B to design the IDPSS before I can clearly explain the approach to her. I then interviewed both learners by phone and Skype twice, each lasting a few hours.

In the next part, I will present my interpretation of their learning by linking their contribution to the proposed approach framework.

Two Learners' Mental Models of Active Reception Learning Theory and Discovery Learning Theory

For active reception learning theory, Learner A took her quote from Driscoll's textbook as the definition: "Reception learning, then, is essentially the same as what commonly occurs in expository instruction, where learners are told information rather than discovering it for themselves" (Driscoll, 2005, p.115). Learner B shared similar definition. Both learners emphasized that prior knowledge play an important role in

learning. When evaluating the research method course, Learner A mentioned that, the instructors' direct, detailed, and step by step instructions enabled her to learn in an easier and clearer way than if she had to discover everything by herself. Being able to obtain tutoring from instructors and teaching assistants in time is very helpful. Learner B designed a composition course consistent with the concept of active reception learning.

As for discovery learning, two learners seemed to hold partially different mental models. For Learner A, in both her writing and conversation with me, she emphasized more than once that discovery learning is: the learner obtains knowledge by herself, and for her own purpose, For example two parts of her writings are:

> The major task of completing this course was to finish one self-designed project in the Ed. Tech. field, and the students had complete authorities to decide the topic. So, for students, completing this course was a process of discovery learning. Since no one told or limited your own thoughts and design, as learner, all the knowledge that students gained during the process was their "discovery", based on Bruner's above definitions of "discovery learning", in my opinion. (from Learner A's document)
>
> Since every group had their unique topics and concerns, the process of finishing the whole project became "A true act of discovery".(from Learner A's document)

When I interviewed her, she mentioned that discovery learning is more appropriate for disciplines involving design as major activities, and less appropriate for disciplines such as mathematics, physics, and chemistry. Because in those design-disciplines,

learners tend to experiment to design something new, for example, a designer might try to experiment the effect of putting different colors together.

She mentioned that her current learning in her job is mainly active reception learning because her work has been mainly based on the templates designed by senior designers. The senior designers are mainly conducting discovery learning because they are completely in charge of a project, and for each new project, senior designers are designing something new, different from their previous design. She also told me that her design of the performance support system was discovery learning because she designed it from scratch without referring to any external sources.

When I asked her that whether discovery learning is in terms of learning processes or learning outcomes, she told me that it is in terms of processes. In her writing, she quoted from Driscoll's textbook: "A true act of discovery … It involves an expectation of finding regularities and relationships in the environment." (p.234). I mentioned two times to her about how Bruner tried to correct the misconception of discovery learning, and according to him, what a true act of discovery learning should be.

Although, she wrote down the notes of "…finding regularities and relationships in the environment", she seemed not to truly understand the meaning of the sentence; otherwise, she would not take "producing something new" and "all by oneself" as her major proofs for a discovery learning and think that it is less appropriate for applying discovery learning in teaching mathematics. I guessed that maybe she had been mis-guided by the definition "Burner defined discovery as 'all forms of obtaining

knowledge for oneself by the use of one's own mind'"(Driscoll, 2005,p.234); or it had been her concept of discovery learning for a long time.

In her writing or talking, she never mentioned "discovery learning model" or "inquiry teaching model" although she emphasized that discovery learning is a process. If she can truly understand the models and the examples of illustrating these models, she might modify her understanding of discovery learning.

By contrast, Learner B has a scheme of discovery learning that seems more consistent with what was discussed in the textbook. In her writing, there were a few parts:

> The role of teacher in discovery learning is to: present typical examples illustrating key features of the to-be-learned concepts and principles, ask medium questions, figure out errors or flaws in the students' reasoning, correct these errors, and help the students modify or improve their mode of thinking. (from Learner B's document)
>
> The role of learner is to: derive a particular concept, rule or principle from the given examples or cases; derive general rules or theories; test, modify or correct their hypotheses.(from Learner B's document)

Then, she presented her design of a course based on Collins and Stevens' model of inquiry teaching:

> First, the teacher presents typical examples of argumentative essays. Some use inductive reasoning and some use deductive reasoning. The

> teacher also presents counterexamples such as the articles full of opinions rather than arguments. Then, the teacher lets the students analyze these examples and generate essential concepts and principles in argumentative writing. During this process, the teacher asks medium questions to reveal what students know as well as gaps in their understanding or flaws in their reasoning. Next, the teacher helps students correct errors and recap the crucial concepts, principles and rules in argumentative writing. In the end, students are required to write one argumentative essay.(from Learner B's document)

From her writing and most of the conversation with me, I thought that she had a scheme of discovery learning similar to what Bruner proposed. However, an interesting thing happened. When I mentioned to her about Learner A's concept of discovery learning, she told me that she kind of agreed what Learner A said, and Learner B's friend had similar ideas by stating it is almost impossible to ask a student to formulate a physical formula as Newton or Einstein ever did, whereas in human science, it is more possible for students to discover. So Learner B thought that both her friend and Learner A are correct for this point.

Learner B stated the discovery-learning-model/inquiry-teaching-model perfectly, and had applied it a few times in real contexts (both in her writing, and her previous design experience), but why did she still agree that natural science is less appropriate for discovery learning? Is the "…finding regularities and relationships in the environment"

same as “formulating a ‘Newton Principle’ by the learner himself”, or “designing something new?” This will be left for our future discussion.

What would both learners think of Bruner’s statement that the goal of education is to train students think mathematically (Driscoll, 2005)? Or if the textbook had introduced the concept in a clearer way, with more illustrations, would the true meaning of discovery learning be more obvious? My own scheme of discovery learning has experienced similar phases as both learners, and today my scheme is still not perfectly clear and stable although I have read the textbook a few more times than two learners. Moreover, the common misconception of discovery learning has existed in the field of education for over 40 years.

Learner B has years of teaching experience, and has applied inquiry teaching model in her previous design. When working on this project, Learner A invested less time than Learner B in reading the book (2 evenings vs. 3 days). Learner A has less experience of teaching than Learner B, and has never explicitly applied the discovery learning model in her design activities; therefore, it is understandable why Learner B has a better scheme of discovery learning than Learner A. Driven by the conversations on this topic, all of our three will pay more attention to discovery learning, and explore what a true act of discovery learning is.

When talking about the relationship between active reception learning and discovery learning, Learner A thought that two theories do not conflict, and their co-existence is possible only at the micro level. At the macro level, it must be

determined that which one dominates, so that the design of learning environment will focus on facilitating the dominant type of learning. Beyond the scope of the project, I am interested in knowing her opinion on the dominant learning in the research method course that she evaluated, and how the environment had facilitated that type of learning.

Learner B summarized the difference between two theories by taking active reception learning as more teacher-centered, and discovery learning as more learner-centered. And she summarized her opinion on the relationships of two theories in the following way:

> Which way of teaching is better? I prefer to have a balance between teacher-centered learning and learner-centered learning. Neither teachers nor students dominate the entire learning process. Teachers should not do the thinking for students and it is critical to cultivate students' problem-solving skills. But they should be able to provide scaffolding or guidance at certain point. It is like kite-flying. Without good control, the kite will finally fall to the ground. A knowledgeable teacher will help students fly higher and higher. In addition, with regard to those fundamental concepts, rules, principles or theories in one subject, the teacher has the responsibility to make them crystal clear to students. It is not hard to understand that more fundamental subjects in one discipline require more knowledgeable teachers to teach.(from Learner B's document)

I would not conduct detailed analysis on every single point that two learners have mentioned, which are left for future projects. For now, my goal is to initiate the external learners' cognitive conflicts, and to prompt their deeper thinking and further reading for clarifying these conflicts. This is the precondition and most fundamental component of trying the IDPSS approach. What they have tried constitutes an important component of their IDPSS. These are their version of operating logic of their IDPSS, at that exact moment, for their applying active reception learning and discovery learning to inform their design.

Maybe after the conversations, if they re-read Driscoll's book, with a different purpose, attending to different information, interpreting differently than they did before, they might modify their operating logic. This process sounds like a discovery learning; however, when they read the book, see how Driscoll summarize Bruner's discussion on discovery learning, are they learning in the way of active reception learning, or discovery learning? The more they understand what Bruner means, the more their scheme is consistent with Bruner's. Suppose that Bruner's scheme of discovery learning is the "provisional regularity", does it mean they are nearer to the "regularity"?

They had read the book when taking the learning theory course. What did they do at that time? Was that active reception learning? I think that it tended to be reception learning, but it is doubtable that it was active all the time. Like what Bruner commented, active reception learning might not happen that much.

Learner A quoted some parts that she thought important, but it did not mean that

she could truly understand all quoted content, and apply them in her practice. This is similar to when I put ID competency standard in OneNote files without truly understanding some of them. When I tried to use the OneNote file, I had to go back to the book to re-read the illustrations. It is the same thing for Learner A, next time when she tries to apply discovery learning theory to design something, she might need to re-read literature on discovery learning, she might either re-read Driscoll's book, or go to the original sources by Bruner or Collins & Stevens (Driscoll, 2005).

With the goal of systematically designing an IDPSS, Learner A might look for some examples applying discovery learning even she does not have the actual needs in her current jobs. Her professional growth would be driven partially by herself other than completely by her job requirements. She would be more self-oriented for creating rather than waiting for the learning experience. Moreover, once the actual needs from her job are there, she would be more well-prepared than otherwise.

Although Learner A has less teaching experience than Learner B, Learner A has lots of experience of being a student. All her previous learning experience constitutes a valuable foundation on which she can relate learning theories to. When I asked her to evaluate the research method course, my intention was that she might be able to learn from how the instructors have designed this course. Since she was the consumer of this course design, she had the direct experience stored in her memory. Why did Learner B choose to design a course when I asked her to evaluate a course? I guess she has the habit of thinking as a teacher, so she wanted to design a course as she often does. What

about Learner A? Can she transfer her past role from as a learner to as a teacher when interpreting her past experience? Can she try to re-design the courses that she has taken, at least in her mind?

Their Understandings of the Proposed Approach of Gaining ID Expertise

I did not show two learners my proposal or explain to them in detail about the proposed approach. Instead, I tried to communicate my intention by asking how they could learn through designing and using an IDPSS by applying two theories.

Learner A felt unclear about my statement for the task of designing a performance support system, So I told her that it is like that I could use the system to assist my designing an instruction, and the system can document my work, after some time, I can draw something useful from the system for a new task. She then designed the performance system, and sent me her document for the design plan. Her plan has a good data-structure for documenting and retrieving her design activities. However, in her document, she did not mention that how this system can assist her learning according to active reception learning and discovery learning.

Then in the phone interviewing, after we discussed about the relationship between two theories, I asked how she would relate her design to two theories. Because I was expecting that she answered my question from the perspective that she was the designer and learner. But, she answered my question only in terms of the user of the system. When I asked her how she could learn from designing and using such a system. She told me that I should have communicated more clearly on whom I was talking about:

the user of the system, or the designer. She said it would be quite different. For the user, because the templates were already there, the user would mainly conduct active reception learning, at least at first. Maybe later, the learner could conduct discovery learning. However, for the designer (herself), she designed the system from scratch, so she was conducting discovery learning.

This reminded me again how easily the role concept might be confused in this approach. So I need to figure out a few different ways for clarification. Then, I produced those figures and tables on comparison of approach 1 and 2, as I will present in the framework part. I hope this visualization way, together with the story and the function, can help other instructional designers understand this IDPSS approach in a clearer way.

When I interviewed Learner B, she told me how she would design a composition course by applying two theories. Then I asked how she could apply these two theories in helping herself gain expertise. She felt this question very abstract even though I hinted that she could transfer the content from writing composition to instructional design, and the learner was exactly herself. Then in our later conversation, I mentioned again this question, and hinted her in the similar way. This time, she seemed to get it and said: “according to discovery learning theory, I might look for some worked examples, analyze them, and then might discuss with others or refer to literature. According to active reception learning theory, I might ask experts or peers for introducing excellent books on design theory, and then I might choose the one most appropriate for me, and start systematic reading of the book.”

Then, I asked her since she has the strategy, how she would choose a media for integrating her strategy. She said that she might set up a blog, and write down her learning. When I asked her what software she could use to help her organize and retrieve information for future use, she seemed to not have much idea for this question.

Learner B represents a typical group of students in our program: they have the strong background of teaching, but are not so good at technology skills. She admitted to me that she knew that learning new technology skills is important for an instructional designer, but her prior knowledge on this is low, and her motivation and self-regulation of learning technology skills is not strong.

I told her maybe learning about technology skills is not that difficult like what she thought, and what she needs to do is to be more interested in technology, and invest more time with more effective learning strategy. I suggested that she might want to design a course plan for her learning technology. Although the core of our field is instructional design theory, eventually, most instructions will be delivered through digital media more or less. So, at least, she needs to be very clear about what technology might facilitate learning and in which way. By contrast, Learner A is very good at technology skills, and her fast reaction for designing a performance support system by using some database concept can prove it.

Therefore, (a) if Learner A and Learner B can work in a group; (b) if their sub-tasks are not to finish the part that each person is good at; if Learner A is required to finish the course strategy design part, and Learner B is required to finish the media choice and

integrating part; and (c) if they can help each other in terms of teaching each other the necessary knowledge and skills, then, ideal learning outcomes might be achieved for both learners. In this way, two learners can become an important part in each one's IDPSS. And they two have already become an important part of my IDPSS. My collaboration with two learners have just started this proposed approach of gaining ID expertise; for all of us three, in the professional growth road, the formula must be 1+1+1>3.

With the contribution from two external learners, I can produce the framework for the proposed approach of gaining ID expertise.

The Framework for the Proposed Approach

The outcomes of this design-based research project include three parts: the IDPSS as the artifact, the case study of my own learning, and the framework that can be adopted by other instructional designers. In this part, I will discuss the framework by integrating the contribution of two external learners.

The benefits of gaining ID expertise through the approach of IDPSS

In order to help you understand the benefits of my proposed approach, I am going to compare two approaches of gaining expertise.

Approach 1 is defined as: Instructional designers gain expertise while designing instructions for other learners in their daily jobs. During the practice, they might read ID literature, collaborate with other designers/experts, and reflect their practice and learning. (See Figure 4)

Approach 2 is defined as: there are three sub-phases in each period of gaining ID expertise: (a) Instructional designers self-design an IDPSS; (b) In their daily jobs, they collaborate with the IDPSS to design instructions for others, and they enrich the IDPSS by recording their ID activities in a structured way; and (c), and they might refine the IDPSS based on their evaluations and reflections. (See Figure 5)

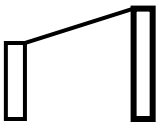
	Period1	**Period2**	**Period3**
As Learner	Previous Learning	Read ID literature, collaborate with other designers, and reflect	Repeat
As designer		Design an instruction for others	
Expertise Growth in Approach 1	Before Period 2 	Growth during Period 2 	After Period2 

Figure 4*: Approach 1 for Gaining ID Expertise*

<table>
<tr><td colspan="2"></td><td>Period1</td><td colspan="3">Period2</td><td>Period 3</td></tr>
<tr><td colspan="2"></td><td></td><td>Phase2A</td><td>Phase2B</td><td>Phase2C</td><td></td></tr>
<tr><td colspan="2">As Learner</td><td>previous learning</td><td colspan="3">Read literature, collaborate with other designers, and Reflect</td><td>Repeat</td></tr>
<tr><td rowspan="2">As Designer</td><td>For oneself</td><td rowspan="2"></td><td colspan="3" rowspan="2">Design IDPSS → Design an instruction with IDPSS → Evaluate IDPSS</td><td rowspan="2"></td></tr>
<tr><td>For other learners</td></tr>
<tr><td colspan="2">Expertise Growth in Approach 2</td><td>Before period 2</td><td colspan="3"></td><td>After period 2</td></tr>
<tr><td colspan="2">Approach1 v.s. Approach2</td><td></td><td colspan="3"></td><td></td></tr>
</table>

Figure 5*: Approach 2 for Gaining ID Expertise.*

The height of the rectangular represents the expertise level, so it can be seen that expertise growth in Approach 2 is bigger than Approach 1 within one period of time; therefore, from long term, an instructional designer probably gain expertise faster by adopting Approach 2.

Please refer to Figure 6 for the role and activities differences between two approaches.

Approach 1	**Approach 2**
Only explicitly design instructions for other learners	Explicitly design instrucions for both oneself and other learners

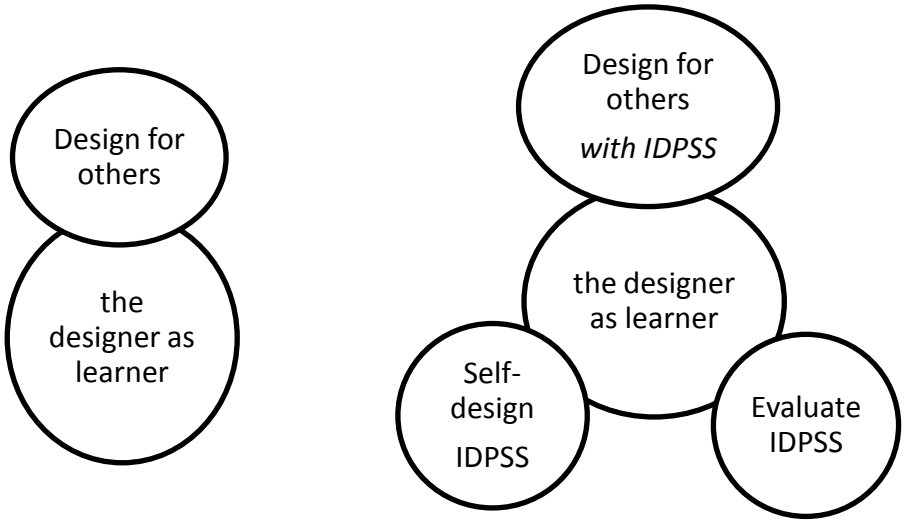


Figure 6*: Comparison of the Roles and Design Activities in Approach 1 & 2.*

Please refer to Table 3 for more comparison of Approach 1 & 2.

Table 3*: Comparison of Expertise Growth in Approach 1 & 2*

	Approach 1	**Approach 2**
The goal	Less explicit and self-orientated	More explicit and self-orientated
The efforts	Tend to be unsystematic and discrete	Tend to be systematic and continuous
Speed of Growth	Slower: within each period, mainly gain experitse through daily job commitments	Faster: within each period, gain expertise through three phases of design activities
Design with IDPSS	No, an explicit and systematic IDPSS does not exist	Yes, assisted with an explicit and systematic IDPSS
with DBR	Less tend to integrate the concept of DBR into one's own professional growth	More tend to integrate the concept of DBR into one's own professional growth
DBR documenting tool	No	IDPSS can potentially become DBR documenting tool

Through the above analysis, it can be concluded that Approach 2 (the proposed approach in this project) is probably better than Approach 1 for helping an instructional designer gain ID expertise.

Tackle the Possible Role Confusion

If you agree with my analysis in the last part, you can try to design your own IDPSS according to the following suggestions.

In order to help you understand your role as learner and designer, I will introduce a fantasy story: a robot comes from Venus. The robot is able to copy everything in terms of capability from a human being that she meets when landing on the earth. Now, let us imagine that the robot happens to meet you, and copies your capability. The robot asks you whether you can help her design a performance support system for gaining ID expertise.

Now, stop thinking about the illogical, fantasy parts of this story, and just focus on the fact that you need to design an instructional design performance support system for a robot that has similar capabilities and characteristics as you. Let us further suppose that the robot can get any resources as you can. The reason why I bring up this story is that I feel that it might be confusing to undertake the role of both designer and learner if the learning content happens to be instructional design.

If you don't encounter this confusion at all, you can just ignore this story. If at any point, you are confused like I was sometimes, you might try my story, or create your own to help you distinguish your role as a learner from a designer. You can also try the function that I mentioned before, or revisit the part illustrating the benefits of my proposed approach.

Start From Learning Theories

As each designer has his/her unique prior knowledge on learning theories, what I suggest here is to find a book on learning theories. I would strongly recommend Driscoll's textbook. You can choose yours according to your needs.

Try to think about what might be some controversial views in our field. What might be some common misconceptions? For example, the followings are a few points that I summarized according to my own experience:

1. Driscoll's comments (see her book on Page137) on cognitive load theory: what might be peripherally related to learning (reduce extraneous cognitive load)? What might be truly important for learning (enhance germane cognitive load)?
2. When designing an instruction, if we focus solely on reducing extraneous cognitive load in hypermedia design, what important things might we miss according to Point 1?
3. About the debate on "why minimal guidance will not work", what is your opinion, and how do you support your position?

You can look for more questions from various sources, such as journals, Driscoll's textbook, or Bruner's works. With these questions as cognitive conflicts, you might engage in re-reading literature on learning theories for solving your cognitive conflicts.

With the above efforts, it might be time for your decision on how to create a consilience tool (see the analysis on why and how I have designed my consilience tool) for yourself. Learning theories are the core of the core in our field. Time after time,

revisiting learning theories might be necessary as you accumulate practical experience. Criss-crossing should become a habit in your reading, each time you read a book or an article, you have different prior knowledge, with different purposes, and therefore, you might learn something different.

When choosing literature, it is necessary to choose both newly published literature and literature published many years ago. Excellent textbooks are good guides on what to read. Bruner's works cover a long time-span, and I find it very helpful to read most of his works. Driscoll (2005) summarized Bruner's works in an excellent way, but Driscoll obviously did not record Bruner's (1996) later evolution of his theory on three modes of learning. Therefore, truly understanding a theory might often require more extensive reading.

Before I read Driscoll's textbook, I read a book called *Psychology* by Peter Grey. This book is excellent for beginners who learn about psychology, and I found that it was much easier for me to understand this book than Driscoll's book. One reason might be that Driscoll's book is for more advanced readers. If you have little prior knowledge on psychology and educational psychology, you might find that her book is abstract in some parts. Therefore, the choice of book is key for engaging your reading, so you have to consult from experts or experienced peers, and to read a lot to discover those appropriate for you.

Finding a Source of ID Competency

I adopted IBSTPI ID competency standard (Richey et al., 2001); you might use the same one or look for other ID competency standards. Good ID competency standards can be benchmarks for your practice. Most basic concepts and tools in our community are expressed by the competency standard. You need to self-examine how well you understand these concepts. I have often found that I have misunderstood some basic ID concepts. Moreover, you can determine the knowledge and skills that you need to obtain. An interesting, and motivated way to use a competency standard is to compare it with some job descriptions and some self-introductions by ID companies from their websites. You will have a clearer vision of our fields, and see what your direction might be.

You might want to create a set of checklists for your daily ID activities, and often the competency standard can assist you in creating these checklists. You need to have a big picture of our field, and a deep understanding of the relationships between various sets of knowledge and skills. Conducting my recommended analysis might help you achieve this goal (see my previous analysis on the relationship between *theory of instruction*, *instructional design*, and *design-based research*).

You might want to acquire some marketing knowledge, such as through taking the course “Marketing Yourself” offered by www.econcordia.ca. This type of knowledge is important not only for your career advancement, but also for your daily ID job because you might often need to market ID services or products.

Research Skills and Communication Skills

Research skills are not only important for researchers, but also for our designers. Or, stated in another way, we should try to be researcher-designers.

When I mention communication skills, I want to emphasize interpersonal communication skills. I find the knowledge of interpersonal communication can provide unexpected insights in understanding our field. Group collaboration is becoming a more important component in learning, so the knowledge of interpersonal communication and group dynamics might enlighten our practices from a perspective that we might not get from learning theories. Often it might be ineffective communication between group members that obstructs effective group learning. Moreover, as DBR emphases the collaboration between participants, effective communication is an important factor ensuring the success of DBR.

Our field was built on communication theory, and there has been a vast body of research in the field of communication, but have we informed our practice by the development of communication theory literature? I cannot know the answer without doing further research. I am thinking about the possibility of integrating continuously developed communication literature into message design, so that learners might collaborate better due to the structure of the learning material and activities. This is only my intuitive feeling and conjecture.

I would recommend that instructional designers take a course such as "Interpersonal Communication", or choose an excellent University textbook on this

topic to read. As I know, there is such a course in the department of Applied Human Science at Concordia University.

Media Variety

We might focus enough on the new technology, such as the internet, but ignore that some excellent sources of knowledge come from outside of the Internet or the digital world. We should be open to all artifacts that human beings have developed over a long history. On the other hand, for the rapidly developing digital technology, we need to explore the factors that can facilitate learning, educational research, and instructional design.

Engage in Mindful-Learning Activities

Designing an IDPSS without engaging in mindful-learning activities will not help you learn. Your IDPSS should be built based on your deep-level processing of the information that you have accessed from external sources. You not only need to remember and understand, but also analyze, synthesize, evaluate, and create. You need to experiment and discover your particular way of thinking in multiple modes.

Both Interpersonal and Intrapersonal

You not only need to collaborate with peers and experts, but also need to give yourself enough time for deep-level thinking. If discovery learning is more about what is already in your mind, your own independent, alone-time thinking is as important as discussing with others.

Enjoy Our Profession

I find that the knowledge in our field is extremely relevant to our daily life. I often can give my friends some suggestions on how to learn. It is amazing to see the potential of educating my daughter in a more professional way. Moreover, whenever I watch a movie or TV program, I can relate something to learning theories, which is a fun activity for me. I hope that you can enjoy this profession too.

Conclusion

This project has produced an artifact, the IDPSS, which has engaged me in learning ID knowledge and skills effectively. Moreover, with the contribution from two external learners, a framework for the proposed approach of gaining ID expertise has been designed. I am expecting that other instructional designers can benefit from this approach.

Working on this project has been an extremely rewarding experience for me. Last August, I was not confident about my future: I doubted whether I could find a professional job in Canada. I mainly worried about my English writing and speaking ability. Today, my written English has been improved a little, and my spoken English has stayed at the same level due to my lack of practice. However, I am confident that I can improve my English ability just as I can improve my ID competency, and these two activities should be integrated closely. If I have the determination and confidence to learn, if I know how to learn, and if I am self-regulated enough to learn, how can learning not happen? And then how can I not find a professional ID job?

My proposed approach is not an easy path to follow; instead, it requires enhancing germane cognitive load. Moreover, how many instructional designers can have so much time (over half a year) like me, to work intensively on designing an IDPSS? Therefore, I hope that my efforts can establish a good start for other instructional designers. Beyond this thesis project, I am interested in building a formal learning environment, such as a goal-based scenario, to engage instructional designers in learning ID knowledge and skills, in a way similar to what I have tried.

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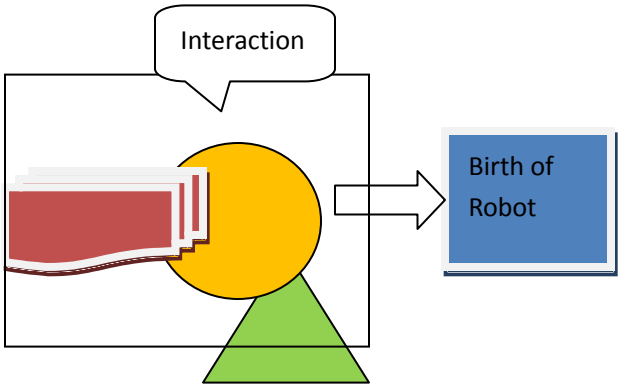
Appendices

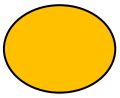
Appendix A: A Sample of the Story-Telling Thinking

Note: this document was created in the initial phase of the project, and has been modified a little for the DBR part. At that moment, the concept of *AI in reverse* was still a little abstract for me, thinking about this imagined story has helped me thread out the complicated processes. However, as I mentioned in my writing, there has been some adjustments, so this story cannot represent the current principles of the proposed approach completely.

Chapter 1: The birth of "Robot Kathy"



Outside resource→ Resource: 

Human mind→ Fengbin: 

Cognitive tool→ Robot Kathy: 

Task: 

Figure A: The "Birth" of Robot Kathy. It is used to represent the initial phase of designing the cognitive tool. Robot Kathy was born due to the interaction among Outside resources, Fengbin, and the task of designing the Robot Kathy.

Fengbin has conceived the idea of designing a Robot to help her achieve the goal of

professional growth in instructional design, after some research and brainstorming, she designed the Robot Kathy, this is the process of AI, Fengbin embedded some intelligence into Robot Kathy (Please see the figure).

At the first place, Fengbin notices the existence of some intelligence, but she cannot remember and understand all, not mentioning the fully application of the intelligence into problem solving. But anyway, Fengbin puts the intelligence into Robot Kathy. Fengbin hopes that next time, when she works on a design task, Robot Kathy can use the embedded intelligence to help her. Fengbin also hopes that little by little, she can internalize some of the intelligence of Robot Kathy. In order to achieve this goal, Fengbin embeds the intelligence in an explicit way.

Chapter 2: As a good cognitive partner, Robot Kathy assists Fengbin to work on tasks. The interaction among Resource, Task, Fengbin, and Robot Kathy creates 3 results:

1. Task is done. Fengbin can deliver the product.
2. Fengbin gains expertise partially because that she AI in reverses the intelligence of Robot Kathy. Remember, in Chapter 1, when Fengbin embedded the intelligence into Robot Kathy, she still could not apply well that intelligence. Now, she not only fully applies well, but also internalizes that intelligence into her own mind, the intelligence/skills become automated. So Fengbin has successfully AI in reversed.

   Moreover, she evaluates whether some Embedded-Intelligence can be improved, then she updates the Embedded-intelligence.
3. As a result, Robot Kathy grows too. Robot Kathy documents Fengbin's

problem-solving- process into the database. Fengbin wants to use the data in many ways, such as analyzing how the learning theories have worked in the context of this task. Fengbin wants to use mathematics, economics, accounting, and literature knowledge to help her make sense of learning theories, and hopefully, she can create some inter-disciplinary intelligence. Fengbin also hopes to refer back to the data when encountering similar instructional design tasks later.

Chapter 3: A new task appears, Fengbin has grown, and Robot Kathy is a brand new updated version now. The new cycle begins.

Chapter 4: the myth of AI (embed intelligence into the robot) and AI in reverse (learn from the robot).

Robot Kathy asks Fengbin: “since you embedded the intelligence into me, what is the need for you to learn from me?”

Fengbin: Hi Robot Kathy, although I embedded the intelligence into you, it is not necessary mean that I have mastered these intelligence. I indeed tried to understand and obtain the intelligence when I designed you, but the fact is that I did not master all. I need to practice more in more concrete situations from more different perspectives, to fully internalize some intelligence.

People often make the mistaking assumption that accessing to knowledge and skills is enough to help them solve problems; unfortunately, it is not.

Chapter 5: when can Fengbin do best, when can Robot Kathy do best? White Box v.s. Black Box

Robot Kathy: Fengbin, do you mean that if you have completely internalized my intelligence, then you will not need me any longer?

Fengbin: Come on Robot Kathy, don't be silly! Remember? The purpose of my designing you is not solely for internalizing your intelligence. In many situations, even though I know how to solve a problem, my speed of working will always be slower than you. You also play the perfect secretary role. I need to focus my energy and time to do things that I am best at, and Robot Kathy, you will always be my good cognitive partner to do things that you are best at.

Sometimes, in order to learn from you, I embed intelligence into you in a white-box way, which means I can see every single detail of solving problems. After some time, if I become familiar with these techniques, I will change the white box to black box. When I work with the black box, I simply give my inputs to you, and you work by yourself without showing me how you are working. This means as a team, we are cooperating to solve the problem, and you completely undertake some tasks, so I can have more time to do other tasks.

Besides even for the intelligence part, you are not a Robot that does not grow; by contrast, you grow all the time as me. Whenever I interact with you, you grow, you obtain new intelligence that I can AI in reverse.

Chapter 6: how Robot Kathy grows?

Robot Kathy: Fengbin, it is great to know, but why that happens? I don't understand how I grow.

Fengbin: To answer this question, I need to tell you that what functions have been embedded into you by me. First, you can help me document my problem solving processes, so each time I design or review a case, correspondingly, you enrich your database. Second, when you document, you are doing it in a structured way, and you are capable of doing further analysis because of the structure. Third, after certain period, I will enhance your structure when I grow myself.

Robot Kathy: I seem understand, but could you give me some examples?

Fengbin: All right, for example…..

Chapter 7: Evolving into DBR (Design-Based Research)

Fengbin: Hi Robot Kathy, do you know that the recursive processes of designing you, cooperating with you, and then evaluating you is actually similar to the method of DBR.

Robot Kathy: Can you explain more about DBR?

（To be continued）

Appendix B: Part of the Consilience Tool

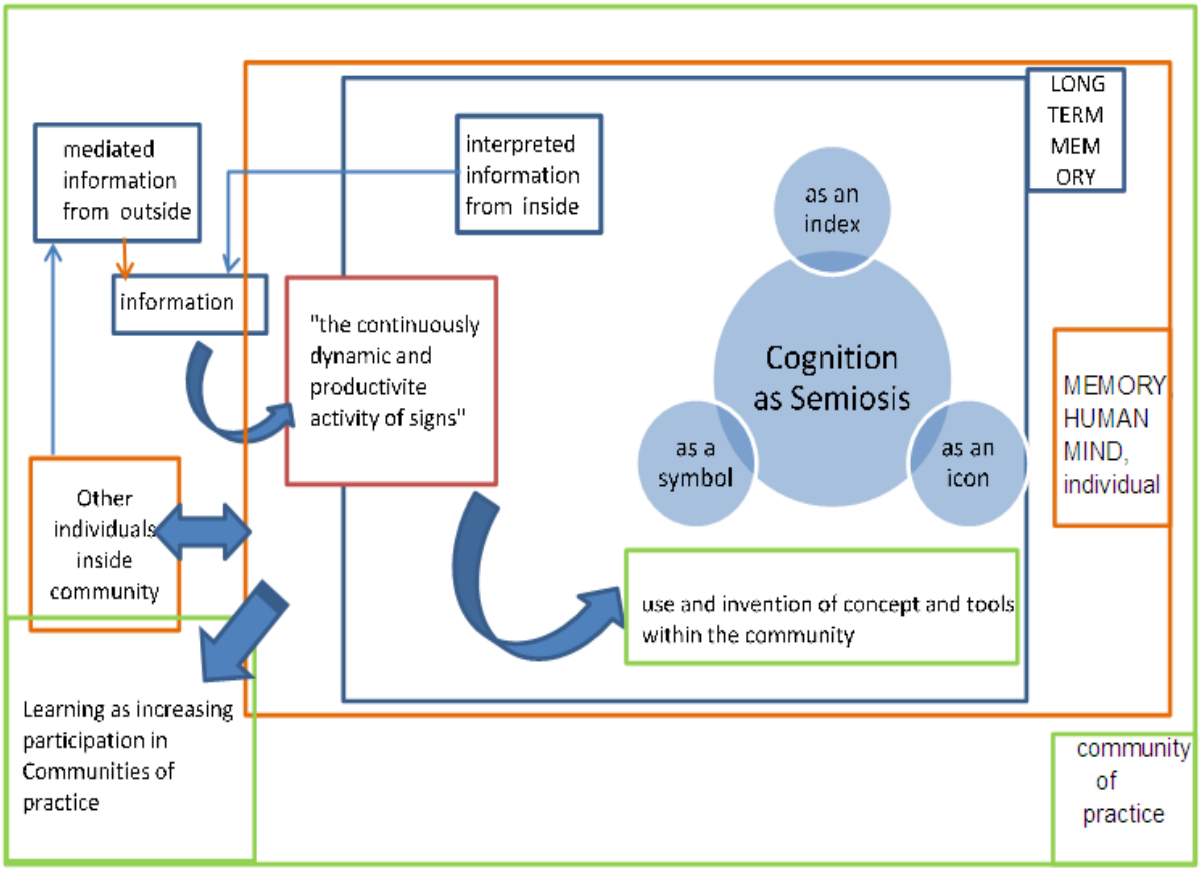


Figure B: ***A Part of the Big Consilience Map: Referred to Driscoll's "Psychology of learning for instruction.*** This map is drawn based on Driscoll's summary on situated cognition theory.

Please refer to the following web address for more information about the IDPSS:

http://education.concordia.ca/~fb_zhao

Appendix C: Part of the ID Tool

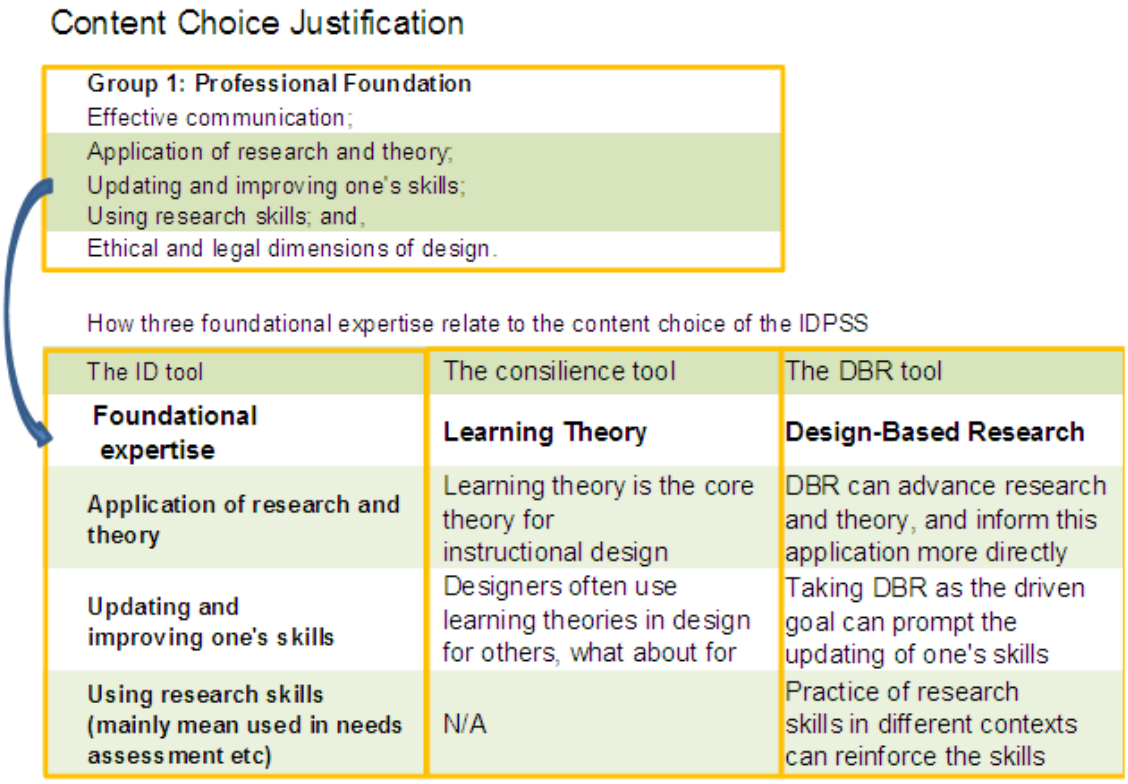


Figure C: ***Using the ID tool to Justify Content Choice***

Appendix D: Part of the DBR Tool

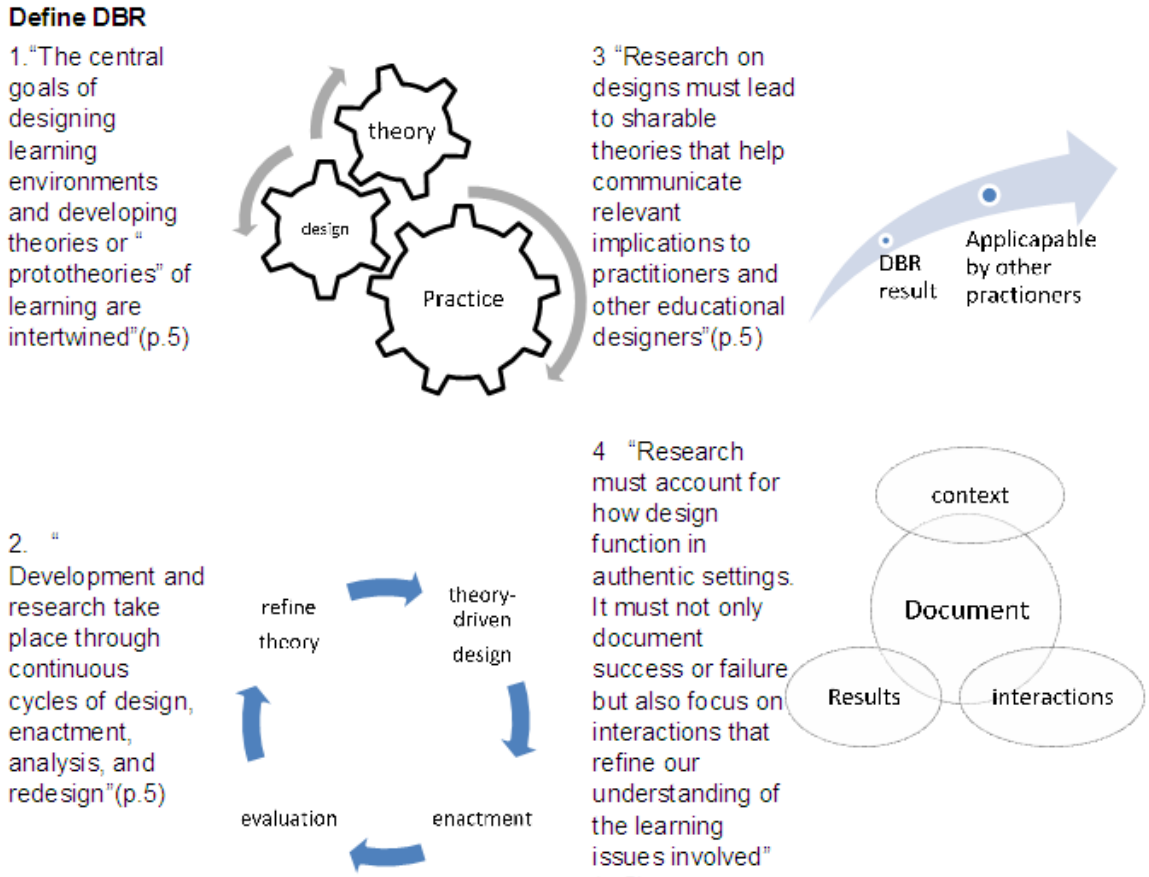


Figure D: Part of the DBR Tool: to visualize the definition of DBR