Design Implications for Teachers' Tools in Differentiated Instruction through Case Studies

Hyunjin CHA*

KERIS (Korea Education and Research Information Service)

Korea

The diversity of students is getting increased in the contemporary classroom. To deal with the diversity, differentiated instruction (DI) should be considered as a way of providing alternative approaches to content, process and product according to the students' readiness, interest, and learning needs. Teachers have problems and difficulties in supporting different student's needs. In fact, teachers need proven tools including framework, guidelines or computing systems to help to practice DI in real context. According to the activity theory, tools influence on how people act and think and even their social practice, playing a crucial role in mediating the activities with people. In DI practice, there are also some studies about physical and abstract tools, but they have been not widely utilized by teachers in real schools. It means that more innovative tool to promote DI might be required. Therefore, to design a better tool to mediate the DI activities with teacher, case studies were conducted. In order to elicit the design implications, two physical and two abstract tools for DI practice were analyzed as case studies. Through the analysis of the case studies, eight design implications better to facilitate DI practice were suggested. This study has implications in suggesting design guidelines for teachers' tools to facilitate their DI practice by analyzing case studies in DI practices for an innovative tool in the educational practice.

Keywords: Differentiated instruction, Universal design for learning, Activity theory, Teachers' tools

* Korea Education and Research Information Service
  lois6934@keris.or.kr

Introduction

In modern society, a variety of technology influences on student's learning style (TLRP, 2010). Through globalization, the interaction between countries is also getting dynamic (Ahn, 2010). Furthermore, it is expanding the opportunity for the disabled students to participate in the general education due to the inclusive classroom. From these social phenomena, the diversity of students in the classroom is getting increased such as diverse backgrounds, learning styles as well as learner's performance levels. In Korea, the diversity at the classrooms has been rapidly increased because of growth of multicultural students, the inclusive classrooms, and the foreign students. Therefore, teachers are facing to support the diverse needs of all students and accommodate their limitations (Rock, Gregg, Ellis, & Gable, 2008). In fact, some studies show that addressing student's diversity and considering student's interest might lead to enhance their motivation and encourage them to remain committed and stay positive (George, 2005; Subban, 2006).

Even if educators and teachers recognize the student's differences, few teachers accommodate these diversities in their classroom (Subban, 2006). In fact, studies about Differentiated instruction (DI), especially in a classroom context (Macro-adaptive instructional model) have not made much progress in the real context due to many difficulties such as the difficulties in developing curriculum designs, teacher training, resource limitation and so on (Park & Lee, 2003). Therefore, it is dominant that teachers actually provide students with a uniform instruction in the contemporary classroom with a hope for the best.

It is prudent to point out that all learners deserve to have an opportunity to engage in learning and to reach their full potential with respect (Subban, 2006). DI should be considered as a way of providing alternative approaches to content, process and product according to the students' readiness, interest, and learning needs (Tomlinson, 2001). Some of teachers might try to differentiate instructions without knowing even its name unconsciously, but they are facing difficulties of the

DI due to a lack of resources or practical strategies and the increased planning time (Subban, 2006). Teachers need proven tools to help to practice DI in a real context (Gibson and Hasbrouck, 2009). In the Activity Theory, the physical artifacts are designed to reflect a history of human's particular use with their social practices (Preece, Roger, & Helen, 2007). Preece et al. (2007) emphasized the relationship between human development and the mediated artifact as a change. The mediating artifacts and human life (activities) are closely intertwined. From this perspective, the analysis on the mediation and tools can understand the context of the practice.

In this study, case studies about teachers' tools for DI practice will be analyzed to elicit teacher's needs on the design of an innovative tool to promote DI practice. In addition, design implications will be derived to design a new computing tool to promote DI practice through new information communication technology.

Theoretical Backgrounds

Differentiated instruction as macro-adaptive instructional model

Tomlinson (2003) emphasized that differentiation did not mean that every student in class must reach to the same objective, but all students should have a chance to perform at their best. In fact, it has been one of the key issues in educational area to support the individual differences. Many researchers (Park & Lee, 2003; Tomlinson, 1999; Winter, 1985) have conducted studies to provide instructional environments and conditions, responding to learner's different needs and capabilities. The details on these studies are a little different in applying instructional approaches and learning process, but the fundamental objectives of these studies were to support learner's needs, using various approaches to facilitating input, processing, and output (Tomlinson, 2001). Even if the terms are quite varied from differentiated learning to adaptive instruction according to the

focus, the instructional methods that have the same foundational goal to support students' needs would be called for the differentiated instruction (DI) in the context of this paper, that Tomlinson (1999, 2000, 2001) defined in the classroom context would be utilized. To illustrate, DI can be classified into three different approaches according to the purpose and the characteristics to be diagnosed: aptitude-treatment, micro-adaptive, and macro-adaptive instructional model.

The ATI Model is mainly concerned about the student's aptitudes to adapt instructional strategies (Froschl, 2005). The aptitude can be defined "as any individual characteristic that increase or impairs the student's probability of success in a given treatment and treatment as variations in the pace of style of instruction (cited in Park & Lee, 2003, p.655)". Even if these kinds of attempts are very appealing to educational researchers, the results are not inconsistent and did not have a big impact on developing adaptive instruction since the studies did not provide feasible suggestions.

Students' needs have been changing while learning is proceeding. The Micro-adaptive instructional models consider the on-task needs by assessing student behaviors and performances rather than pre-task measure, and providing adaptive instructional decisions during the action of the task (Modritscher, Garcia-Barrios, & Gurl, 2004). As adaptive technologies is advancing, a variety of trials (Shute & Zapata-Rivera, in press) attempt to diagnose different status of learner's on-task needs and adapt different instructional strategies to different learners. Thus, it is more dynamic to reflect student's performances and it mainly depends on a quantitative representation (Park & Lee, 2003). However, it was criticized that most of studies about adaptive systems on the micro-level were concerned about acquisition of "conceptual knowledge and procedural skills (p.673)" rather than meta-cognitive strategies and learning experiences (Akhras & Self, 2000).

The DI strategies which Tomlinson (1999, 2000, 2001) has suggested to differentiate instruction in mixed-ability classrooms can be considered as one of the

Macro-adaptive instruction models. The DI as macro-adaptive models could help teachers to build a student-centered learning environment in a classroom by recognizing the learner's diversity and facilitating learning experiences because the constructivist believes that when students are actively engaging in the topics connected to their interests can be a meaningful learning (Smith & Throne, 2007). However, the studies about the model have not made much progress in practicing in the real context due to the difficulties in developing the curriculum design, teacher training, resource limitation, and organizational resistance (Park & Lee, 2003; Subban, 2006). In recent years, computer technology has powerful potentials to tackle these problems, and make an innovative reform on the DI.

To sum up, this study is more concerned about the DI as the macro-adaptive model in the classroom contexts for the following reasons. In a recent year, the diversity at the classrooms in Korea has been rapidly increased because of the growth of multicultural students, the expansion of the inclusive classrooms by the revised law for the disabled, and the rise of the foreign students. Thus, the DI should be an essential instructional part in the Korean schools. However, the macro-level adaptive DI model has not made much progress in practicing in the real context mentioned above. Thus, the aids to support teachers to practice DI in the classroom are needed for education for all (EFA). Moreover, it is necessary to expand student-centered learning environments in the classroom based on the fundamental idea of the constructive theory that pursues to raise student's "problem solving, reasoning, critical thinking and the active and reflective use of knowledge (Driscoll, 2005, p.393)". Therefore, by promoting DI practice, a student-centered learning environment can be also encouraged.

Activity theory

Activity theory (AT) has long its roots, originated from the cultural-historical research traditions. The review of the historical development of AT offers an

insight into the artifact (tools) as a mediated act in the environment that users are interacting (Nardi, 1996). Engeström (1999) distinguished between three theoretical generations in the evolution of cultural-historical AT. The first generation of AT was Vygotsky's triangular model, which crystallized the role of the cultural artifact as a mediated act between stimulus (S) and response (R). It was reformed as the triad of subject, object, and mediating artifact (Engeström, 2001). However, the first generation has a limitation in that the subject was analyzed from an individual point of view, so Leont'ev (2000) described the difference between an individual action and a collective activity, exemplified in "the primeval collective hunt" and the second generation was inspired by his work (Engeström, 2001). He emphasized how the divisions of labor influence on the interrelationship between the subject and the object. Engeström (1999) graphically expanded the Vygotsky's triangular model, integrated by Leont'ev's work of a collective activity, and produced an "activity system" as the expanded triangle model of which include the community, the division of labor, rules. In the third generation, the basic triangle model was expanded to include the interaction between two activity systems with the consideration of the networks of activities.

Role of artifacts in activity theory

The role of artifacts in the AT was also developed through three generations. The artifact simply meant mediation in an interaction between human being and an environment for the behavioral transformation of the individual such as the use of sign systems in the first generation. However, it expanded to be conceptualized as the mediation, collectively involved by the community in the second generation, and supra-individually shared with a wider set of practices in the third generation (Engeström, 1999). Artifacts can be either physical such as a computing system or abstract such as a symbol. The physical artifacts are designed to reflect a history of human's particular use with their social practices (Preece et al., 2007). In addition,

the use of cultural-specific tools even has an impact on how people act and think, so the artifacts would transform the human activities and their way of life (Jonassen & Rohrer-Murohy, 1999). Preece et al. (2007) emphasized the relationship between human development and the mediated artifact as a change by acting on the world to what is mediated by something else. Thus, new activities from new artifacts lead to a new learning, influencing on their culture, society, and even history. Likewise, the mediating artifacts and human life (activities) are closely interwined.

AT is philosophical framework as a descriptive tool to understand human activity and mediating tools (Nardi, 1996). In fact, when designing computing tools, it is one of the difficult tasks to understand and describe the "context", "situation", and "practices", so a richer description of the user's context can make the design much easier and more practical. AT can be a useful handle for understanding how the mediator (tool) has been created, shaped, used and changed in the social context (Bertelsen & Bodker, 2003).

Case Studies

From the AT perspective, DI activities can be mediated by various tools and the tools are shared with the community by creating new rules and divisions of labors among members (Engeström, 1999). Therefore, the tools play a very crucial role in mediating between people and the activities. In order to achieve the appropriate outcomes through DI activities, it is crucial to provide the community with the most suitable tools. The tools can be either physical such as a computing system or abstract such as guidelines. In fact, Gibson and Hasbrouck (2009) also argue that teachers need tools, templates, and proven methods to help them practice DI in their class. However, there are not many tools to support DI activities in a real context. In this study, tools currently utilized in a real context will be analyzed. From these case studies, common aspects to mediate DI practice can be explored,

and activities tools should support can be elicited to promote DI activities.

DI guidelines for implementation by Gibson Hasbrouck & Associates

Gibson Hasbrouck & Associates (GHA) which is an educational consulting company provides "Differentiating instruction guidelines for implementation" based on their experiences and expertise (Gibson & Hasbrouck, 2010). Gibson (2011) emphasized that the implementation of the DI requires changes in practice, and changing the practice requires professional developments. The key steps for implementing DI in an effective way can be summarized as follows (Gibson & Hasbrouck, 2008; Gibson & Hasbrouck, 2009; Gibson, 2011)

Table 1. DI Guidelines for Implementation by Gibson Hasbrouck & Associates

1) Establish the proper environment
2) Assessing students' strengths and needs to align curriculum with needs
3) Using the data to inform practice
4) Creating teaching strategies for managing resources such as time, pacing, and work
5) Creating routines and procedures
6) Providing high-quality DI teaching and practice

She emphasized writing positive, personalized and proactive comments by observing students and using mailbox. The mailbox with individual name on it can be routinely checked by students, who will be assigned different activities from it by adding to their Do/Done folders. However, when teachers manage their students and different resources, one of the problems they face is instruction management. Teachers do not exactly know how to manage instruction for individual learners, so they need tools to manage instruction and satisfy instructional demands. Thus, GHA recommends an instruction management system as a tool to support for teachers. "The instruction management system creates routine and procedures that simplify instructional delivery and help teacher use resources efficiently and effectively (p.18)". It also helps students to participate in learning activities and

collaborate in a group. When teachers get to provide a consistent teaching by the routine, more time and attention can be focused on effective instruction.

SchoolNet – ALIGN module in Delaware district of the USA

A school district in Delaware of the USA developed a strategic plan focused on instruction because it had a stagnant student's performance (Gordon, 2007). One of pillars in its strategic plan is the DI. To help teachers to put into practice, the district adopted SchoolNet, an instructional management system (IMS) that "support data-driven decision-making for schools (p.15)". The SchoolNet has several components. Among them, ALIGN is the module for DI practice. In fact, the ALIGN is a teacher's tool to easily analyze student's information and create differentiated lesson plans by sharing instructional resources. The ALIGN module includes condition, labels, and events that occur in a student's life, as well as gender, ethnicity, and status for analyzing student's information. To facilitate DI by using the ALIGN, the district developed the Data to Instruction (DTI) framework. The DTI process starts with collecting student's information, lesson objectives from the system, and guides teachers to organize instructional needs and to find the appropriate group strategy as shown in Table 2. It consists of grouping students according to the student's RTI level and providing different activities. Good lesson plans that teachers submitted were shared among other teachers.

Table 2. Steps in SchoolNet ALIGN module

1) Classified by RIT (scale to measure a student's progress) scores
2) Determine the needs group
3) Select the goal strand
4) Select the skill and track skill across range
5) Link to PI
6) Formulate essential questions
7) Instructional strategies (DI)
8) Evaluate

Six-Step Planning Model by Gregory

Gregory (2003) and Gregory & Chapman (2007) emphasized that teachers can strategically differentiate in content, assessment, performance, and strategies to provide all students with chances to learn to their full potential. For DI, she proposed tools including the elements in six categories.

To explain each step, first of all, when creating a safe and nurturing classroom climate, building a learning community should be taken into account. Secondly, learning-style and multiple intelligence theories should be understood by teachers to know the student's strengths and weaknesses. Thirdly, teachers need pre- as well as on-going assessment in order to adjust lessons and monitor progress. Fourthly, after examining data, teachers have to choose appropriate grouping strategies and assignments. Fifthly, determining strategies can make a difference in student achievements and lead to student's success. Lastly, teachers may find many useful curriculum approaches such as Problem-Based Learning, Inquiry Models, and Contracts.

Table 3. Six-step Planning Model

1) Identify what needs to be taught (standards, benchmarks, essential questions, expectations to be taught)
2) Define the content (facts, vocabulary, and essential skills)
3) Activate. Activate student's information (prior knowledge, background experience, and attitudes, and preferences)
4) Acquire. Determine new information and skills students need to learn, and strategies that they will acquire the knowledge
5) Apply and Adjust. Provide students with the opportunity to practice and become actively engaged with the new learning
6) Assess. Decide how the students will demonstrate their learning

UDL PAL toolkit

CAST (n.d.) suggests that teachers should practice the differentiated curriculum plan and delivery by utilizing UDL Toolkit, PAL (Planning for All Learners). The PAL Toolkit provides specific planning steps, guidance, model lessons, templates, and links to other educators' samples. It was designed to promote the differentiated curriculum plan and delivery followed by four steps. It is based on the principles of UDL, proven professional development strategies, and effective teaching practices (CAST, 2010). Its main tools are "Goal Setter", "Lesson Analysis", "Class Profile Maker", "Curriculum Barrier", "UDL Solution Finder". In the "Class Profile Maker", student's strengths and weaknesses are analyzed in three different brain network (cognitive, strategic, and affective). Moreover, barriers are also diagnosed according to student's characteristics in each network. Thus, UDL solutions have to be applied based on the diagnosis. Moreover, it consists of useful resources, such as lesson plan examples designed by other teachers. Therefore, educators are easy to follow the process.

Table 4. PAL Curriculum plan and delivery steps

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1) Set Goals
   - Goal Setter Tool
2) Analyze Status
   - Lesson Analysis Template
   - Class Profile Maker based on the three brain network
   - Curriculum Barrier Tool based on the Class Profiles
3) Apply UDL
   - UDL Solution Finder based on both the three brain network and the curriculum
     barrier analysis
4) Teach UDL lesson

Smart-phone version of the UDL PAL toolkit

Cha & Ahn (2011) suggested a smart-phone version of PAL tool to make it

utilized in a more practical way by researching into PAL toolkits from CAST. The smart-phone version was designed by analyzing problems of and improving the web version. It has similar functions and procedures with PAL Toolkit, but the smart-phone version has improved characteristics. First of all, the smart-phone version can be utilized during teaching as soon as teachers find new characteristics or good ideas about instructional strategies for a particular student. It can help teachers to reduce a workload by managing student's information on the process. Moreover, it can also overcome a weakness in the macro-model that it cannot reflect student's changes during process. Secondly, information architects and interface designs were improved, eliminating repetitive activities. Finally, the smart-phone version has an advantage of utilizing anytime and anywhere.
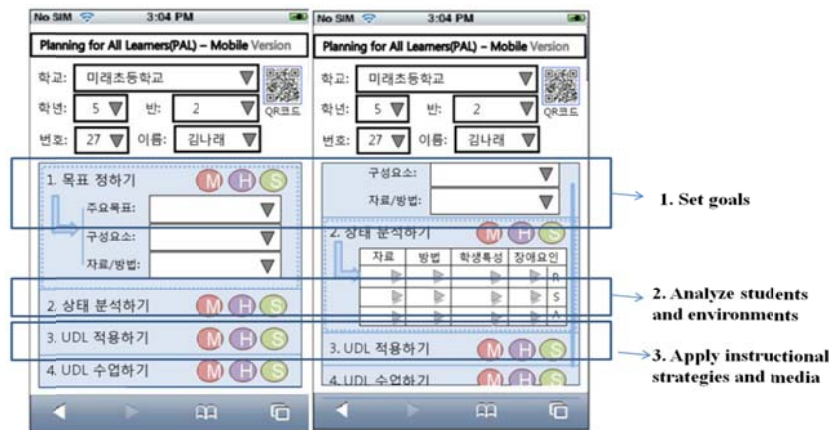

Figure 1. Smart-version of PAL toolkit (Cha & Ahn, 2009)

Analysis of Case Studies

This study reviewed four different tools to help promote DI in practice. Among 4 tools, two (guidelines and model) are abstract and the other two (SchoolNet and PAL Toolkit) are physical. As explained in the AT, tools should play a mediating role in activities to achieve the object among community (Engeström, 1999).

Therefore, analysis of such tools may provide a fundamental basis for design of improved tools (Preece et al., 2007). From this analysis, common characteristics to be emphasized on such tools were revealed to support teachers' DI practice as shown in the Table 5.

Table 5. Comparisons on Characteristics of four tools for DI practice

Characteristics	DI Guidelines	School Net	Six-Step Planning Model	UDL PAL Toolkit
Defining and determining the learning objectives			V	V
Analyzing student's needs using templates	V	V	V	V
Planning a prescriptive instructional design	V	V	V	V
Managing student's data	V	V		* Smart
On-going evaluation and revision		V	V	V
Sharing good instructional materials		V		V
Emphasize on Brain theory (Multiple intelligence, Learning brain etc.)			V	V

Firstly, in order to perform DI, it is important to determine precise learning objectives according to individual student as two tools have the task as the first step. All students in a class do not need to have same learning objectives (Rose & Meyer, 2002), but teachers should find a suitable learning objective for those students in a class based on their characteristics. Thus, analyzing student's characteristics should be done at an early stage. In addition, to differentiate instruction, it is necessary to diagnose learner's needs such as interests, difficulties, as well as performance at early stage. To encourage such activity, tools should provide the function in a more

concise and explicit way. As an example, the PAL tool provides guidelines to analyze student's strengths and weaknesses according to brain networks. In fact, six-step model also recommend teachers to understand multiple intelligence theory. Therefore, professional developments for teachers about brain research might help teachers to practice DI in classrooms.

Thirdly, teachers have to plan a prescriptive instructional design based on the diagnosis of learners. All four tools reviewed in this study have the step to find the appropriate teaching strategies and materials for students. As analyzed above, the resources and strategies could be connected to the brain research (Rose & Meyer, 2002), and flexible grouping can be a good method to differentiate learning emphasized from two tools. Fourthly, managing student's data is an essential part of teacher's role, so two tools suggest a management system. On the smart-phone version of PAL, the student information management system was supplemented to improve the toolkit. In fact, there are so many data to be managed by teachers to practice DI, for instance, student's characteristics, assessments, and so on. Thus, the well-designed management system might serve teachers as an aid. Fifthly, on-going revision in terms of student's interests and needs as well as assessment should be conducted to provide a constant feedback and reflect student's status. Sixthly, it might be very helpful for teachers to share good instructional methods and examples. Teachers feel more comfortable when they have colleagues as a mentor (Lee, Kwon, & Kim, 1999; Rose et al., 2006). Thus, peer coaching can promote teachers by sharing good models in DI practice. Most importantly, professional developments about DI have been emphasized through case studies to facilitate the active participation of teachers. Finally, review of the PAL smart-phone version concludes that advantages of mobile technology might help overcome macro model's weaknesses and provide an efficient way of practicing DI.

Table 6 summarizes implications on case studies of teachers' tools for DI practice. According to AT, how well the tool can be mediated between activities and subjects are very important to achieve objective and outcomes. Thus, eight design implications might provide educational practitioners with guidelines to

design more innovative tools to promote DI practice in a real context. However, in this study, only four tools were studied as cases and it might not be enough to identify all characteristics for design of innovative tools. In fact, there were not many cases to conduct a meta-analysis. This means that tools to promote DI practice have been not widely developed and distributed. As emphasized above, in spite of importance of DI in a class, there are not enough proven tools. From this perspective, this study might have further implications on establishing educational atmosphere to voluntarily put into DI practices through such tools.

Table 6. Implications on the case studies of the teacher's tools for the DI

1) The learning objectives are defined according to individual student
2) Analyzing student's characteristics and needs should be done at an early stage
3) Prescriptive instructional strategies and materials are planned based on the diagnosis of learners including goals, resources, content, and strategies
4) A management system might help to manage such student's data efficiently
5) On-going revision in terms of student's interest and needs as well as assessment of the achievement should be conducted to check student's status
6) It is very helpful for teachers to share good instructional methods and examples
7) Professional developments about the DI should be preceded to facilitate active participation of teachers
8) Mobile device might be useful to provide an efficient and usable way of DI practice

Conclusion

In Korea, the diversity at the classrooms has been rapidly increased because of growth of multicultural students, the inclusive classrooms, and the foreign students. Therefore, teachers are facing to support the diverse needs of all students and accommodate their limitations.

According to AT, tools play a mediating role in achieving objectives for people (Nardi, 1996). It means that when the innovative tool is designed and helps to

mediate the teachers' DI activities, it comes to become a useful tool and give a big impact on their mental consciousness and a nature of their physical activities (Nardi, 1996). From the AT perspective, a research question is to elicit teacher's needs on the design of such an innovative tool to promote DI practice. As the first step to explore the research question, four case studies were analyzed to identify teacher's needs and system requirements, common characteristics and functions to support DI practice were explored. From the case studies, seven characteristics were identified and eight design implications were suggested to help to facilitate teacher's DI practice.

To conclude, the educational atmosphere to voluntarily put into DI practices through well-designed tools which reflect teacher's needs and contexts might encourage DI practice in a more efficient and effective way. It might finally influence student learning motivation and improve their school life in a positive way (Subban, 2006).

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Hyunjin CHA

Researcher, KERIS (Korea Education and Research Information Service)

Interests: Learner Experience (LX), Human-Computer Interaction (HCI),

Universal Design for Learning (UDL), Differentiated Instruction (DI),

Learning Science

E-mail: lois6934@keris.or.kr