A Lesson Study Approach to
Infusing Thinking Skills into the Mathematics Classroom

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Abstract
The explicit teaching of thinking skills in mathematics classrooms is a process by which students can gain a deeper understanding of mathematics; however, it is something not easily put into practice. In Fall 2004, the mathematics program within UGRU, a first-year developmental program at UAE University, incorporated explicated thinking skills objectives into its course documents. In this paper, we report on a qualitative study of a lesson study approach to professional development that enabled teachers to infuse their classes with explicit thinking skills objectives and modeling. This occurred through a process of establishing local expertise, developing lessons, conducting peer observations, and reflecting on and revising the lessons. Teacher views concerning how thinking skills can be defined, identified and assessed in the classroom are shared. The paper concludes with an analysis of the impact of the lesson study approach on the instructors and their teaching.

INTRODUCTION
Providing students with opportunities to acquire and use creative and critical thinking has been put forward as a necessary cornerstone of Arab educational reform [1]. The ability to think creatively and critically, it is argued, will enable Arab students to participate in and contribute to an ever changing world. These recommendations are often advanced because of the projected demands of the work force in the 21st century, but they also reflect awareness that skillful thinkers have a better chance of taking charge of their lives and achieving personal advancement and fulfillment. Today’s young people must be prepared to exercise critical judgment and creative thinking to gather, evaluate, and use information for effective problem solving and decision making in their jobs, in their professions, and in their lives. In other words, students must develop thinking skills in order to be a contributing member of society. Despite awareness of the need to foster critical and creative thinking in students, both higher educators and industry complain that today’s students lack thinking skills. Although textbooks and curricula are changing in order to help bring about a greater focus on thinking skills, it is, in the end, the classroom teacher who, through day-to-day instruction, must assume the main responsibility for helping students to acquire these skills. The efforts that are required to meet this goal must, therefore, be directed at effective classroom implementation. While infusing thinking skills into the curriculum is often talked about, the process of how to put the theories into classroom practice is less clear. This is precisely the impetus for undertaking the project described in this article.

In fall 2003 a set of Curriculum Competencies were adopted within UGRU, the first year developmental program of the United Arab Emirates University. These competencies represent the learning outcomes students shall have performed upon completing their UGRU courses. The competencies include learner training, thinking skills, application of knowledge, information literacy and communication. They are, in essence, the skills, knowledge and dispositions students need to be successful in university and beyond. During spring 2003 specific learning objectives related to the UGRU Curriculum Competencies were woven into the UGRU Mathematics program course documents. Specifically, teaching and learning objectives regarding thinking skills were added to the set of content objectives in the student calendar (course syllabus), and teachers were asked to incorporate these objectives as part of their course objectives. While these
objectives existed on paper, classroom observations and discussion with instructors indicated that their implementation in the classroom was limited. Teachers themselves could readily point to topics which presented “thinking” difficulties for students, but they were not clear about what thinking skills are, and whether, and if so how, they could be taught. A more focused approach was required. This paper highlights an initiative developed in response to the classroom challenges faced: The UGRU Thinking Skills Group (TSG). The findings indicate that the process of locally addressing the need to include thinking skills through a lesson study approach can produce classrooms that meet the desired goals surrounding student acquisition of thinking skills in a Middle Eastern Mathematics program.

BACKGROUND

The thinking skills movement of the 1980s and 1990s has produced a substantial body of research through which three main principles have emerged: 1) The more explicit the teaching of thinking, the greater its impact on students, 2) the more classroom instruction incorporates an atmosphere of thoughtfulness, the more open students will be to valuing good thinking, and 3) the more the teaching of thinking is integrated into content instruction, the more students will think about what they are learning. These principles provide the basic rationale for infusing thinking skills into content instruction. And while some may argue that the opening words of the second Sura of the Holy Quran (Alif lam mim – This Book is not to be doubted) is an indication that knowledge is to be memorized and recited only, not thought about, there in fact exist more than 114 different verses of the Holy Quran addressing the positive attributes of “thinking skills” (يتفكرون، يعقلون، يفقولون، يتساؤلون). In Sorat Al Bakara alone we find 8 Ayat where thinking is mentioned. In fact, if we add Ayat where the Quran encourages people to think, investigate, and understand we find nearly 350 Ayat referring to thinking skills [2]. In more general terms, Sura Taha, Ayat 114 and Sura Al Zomar, Ayat 9 both encourage women and men to seek knowledge, and praise those who look for life-long learning.

One of the most commonly used definitions of thinking skills in the Arab literature is “Thinking skills are cognitive processes that enable us to make meaning from, and create with, information” [3]. Often included under the definition of thinking skills are habits of mind and/or thinking behaviors that define attitudes and dispositions of good thinkers. The thinking skills definition(s) and activities that are most often adopted in the Arab world are essentially the same as the ones used in the West, and there appears to be little attempt to write a definition of the thinking skills that reflects the Arabic mind and culture. In the literature available in this field the majority of materials are simply translated versions of Western originals. The use of these materials, locally translated but developed elsewhere, can lead to mistrust among teachers in the Middle East towards their workshop facilitators, as well as in the subject itself. That Arab educators have chosen to adopt Western models is strange considering the fact that the subject of thinking skills is, as mentioned above, so prominent in the Holy Quran. Perhaps it is an inherent knowledge of these ayat that continues to lead educators in the Arab world to work towards bringing thinking skills into Middle Eastern schools. Efforts to date, however, have met with limited success, as highlighted below.

Regional Thinking Skills Efforts

One of the largest efforts to promote the teaching of thinking skills in a Middle Eastern educational system comes from Saudi Arabia where - despite large-scale, expensive teacher development activities - efforts to infuse thinking skills into the school curricula have seldom made it past the teacher training stage. Al Watan Newspaper reports that regular workshops for teachers in Jeddah Zone and other districts have been occurring since 2001, yet teachers continue to teach the content in the traditional way with little emphasis on thinking skills [4]. This project has included the development of a teachers’ guide to help teachers explicitly teach thinking skills. It was believed that the combination of teacher development workshops and the printing of 450,000 copies of this guide would enable teachers to teach thinking skills. The results, however, have not been promising, leading to the development of a second project focused on activating the use of the teachers’ guide to develop thinking skills. At present, this effort is at a critical phase
with “...teacher attendance dropping dramatically because of lack of interest” [5]. With so much time and money having been invested, the Saudi Ministry of Education is finding it difficult to announce the death of the project, despite its obviously limited success. What can be learned from projects such as this is that top-down initiatives will do little to help bring about the infusion of thinking skills into the classroom.

Within the United Arab Emirates, the Abu Dhabi Education Zone established in 1999 a center for improving students’ thinking skills. IDRAC, the center, has established itself as a leader in the thinking skills movement in the UAE. It is the sole representative of Edward de Bono’s thinking skills courses in the Arab region, and has also established strong relations with the National Center of Teaching Thinking (NCTT) located in Boston, Massachusetts. IDRAC has translated several books on thinking skills into the Arabic language and also developed a new approach, the School Wide Optimum Model (SWOM), for infusing thinking skills into the K-12 curriculum. Contrary to many initiatives in the region, this model was designed taking the Arabic culture in account. The theory behind the approach, infusion, has also been adopted in many schools in the US. To date, little evidence of positive impact of this approach has been published, and after seven years few schools have fully implemented the SWOM.

These are just two examples of programs in the Middle East focusing on incorporating thinking skills into curricula. However, despite the large-scale efforts, teachers in most educational settings in the Middle East continue to struggle to fully implement thinking skills instruction into their content area classrooms. We argue that this is due in large part to the top-down nature of the initiatives. Without direct teacher involvement in the process of infusing thinking skills into the content area classroom, there is limited local ownership and understanding of thinking skills on the part of teachers, and in turn students, and, therefore, little effort to build thinking skills into classroom practice. For that reason, we undertook an effort that would enable UGRU instructors to develop their own local understanding of thinking skills, and the means to infuse their own understanding of the concept into their lessons in such a way as to promote student acquisition of thinking skills. The degree to which this has been successful will be presented in the discussion section. First, however, we will outline the procedures of the approach and the locally developed knowledge.

THE UGRU THINKING SKILLS GROUP PROCESS

Setting
The University General Requirements Unit (UGRU) of the United Arab Emirates University is a first year developmental program that has as its mission equipping students with the relevant knowledge and skills needed to function as a competent member of the university and society. The UGRU curriculum focuses on both the process and the product of learning in order to develop students with a mastery of the subject-specific core competencies who can also create, use and communicate knowledge [6]. The UGRU curriculum seeks to develop individuals with the life-long learning and thinking skills essential to life in our rapidly changing world. In an effort to fulfill its mission, the UGRU Mathematics program seeks to promote in its students development of personal and educational skills that will enable them to become responsible partners in a student-centered approach to learning through three course offerings – Intermediate Algebra, Probability and Statistics, and Pre-Calculus. Essential for meeting desired program and UGRU outcomes is the development of its students' abilities to think critically and creatively, work cooperatively, communicate clearly and develop general numeracy. Beginning in Fall 2004, the 50 UGRU mathematics instructors were asked to incorporate more learner training and thinking skills objectives into their mathematics teaching. Initially, a regular series of professional development workshops were presented to UGRU mathematics instructors, with the objective of assisting them in implementing reforms in the mathematics curricula aimed at better fulfilling the mission of UGRU. These sessions focused on issues such as lesson planning, informal assessment, cooperative learning, working with English Language Learners in the content area, and incorporating learning strategy objectives into daily lesson plans. Overall,
feedback regarding these sessions was positive, and a number of instructors reported on the effectiveness of specific strategies promoted in these workshops. Still, the desired embedding of the UGRU Curriculum Competencies into classroom practice was inconsistent. This was particularly true in the area of infusing Thinking Skills throughout the curriculum, as evidenced by limited inclusion in instructors’ daily classroom activities. In response to these teachers’ calls for a deeper understanding of what thinking skills really are and how they can best be incorporated into the classroom, a core group of 12 mathematics instructors was organized to examine the issue during the spring 2004 semester. The project aimed to combine research into the concept of thinking skills and their place in the classroom with practical work on the development of lesson plans for activating thinking skills in the mathematics classroom. In addition to the 12 instructors, two facilitators, the authors, took part in this project. The overall structure of this project was based on two important concepts: Communities of Practice and Lesson Study.

Communities of Practice and Lesson Study

In a system founded on the concepts of Communities of Practice and Lesson Study, the researchers’ role is by nature participatory [7]. Within these concepts, it is vital that issues for study are those that arise from the participants (instructors) themselves, leading to a blurring of the distinction between “researcher” and “subject”. Underpinning this concept is the idea that learning is a social activity in which the involved parties both create and constrain opportunities for the other [8]. Inherent in this position is the understanding that the cognitive and social are strongly interconnected in the process of acquiring new teaching practices. In other words, opportunities to learn how to infuse thinking skills modeling into one’s teaching practice arise or are constrained as a result of how a given setting is socially organized, how people act towards one another within the setting, and through what is said to one another. The evidence is clear that simply running workshops about the concept of thinking skills and telling teachers to put thinking skills objectives into their lessons was not effective. Instead, we sought a means to work with teachers to identify what thinking skills are and where they show up in the classroom, and then together identify and develop appropriate strategies for conveying the needed skills, knowledge and dispositions to students. Our research goal in this project was not to judge the interactions and actions surrounding the modeling of thinking skills in the mathematics classroom, but to try to better understand the process within the co-constructed context of the interactional events and discourse related to the issue of promoting student use of thinking skills. This includes documenting the local definitions and concepts identified as well as participants reactions to the process. This can best be accomplished through detailed description, through observing what the involved parties do, and by listening to what they say and have to say. Throughout this papers, pseudonyms will be used whenever quoting a participant directly.

The concept of Community of Practice is based on Lave & Wenger [9], Wenger [10] and Wenger et al.’s [11] theories of learning as social participation in the workplace. The model starts at the institutional level where the people for whom professional development is intended, the instructors themselves, select topics related to their needs. This provides ownership of the process from the outset and helps maintain reform momentum. As the professional development cycle unfolds the responsibility for change shifts from the initiators of the reform effort, program administrators and the researchers, to the mathematics instructors themselves as they develop communities of practice. The intended final phase of the cycle is a ‘community of practice’ component where lead local instructors take on the role of the facilitators and begin to share, as colleagues and friends, forming a Faculty Learning Community [12]. In essence, instructors take ownership of their own and their peers’ continuing professional development. To strengthen the development of a community of practice, we also incorporated a Lesson Study approach.

Lesson Study is an approach to professional development that puts instructors at the center of an examination of teaching practice [13]. As with the community of practice, in the lesson study approach instructors begin by choosing an area of interest, and then establish local knowledge through research and literature review. Thus, the first step for the twelve instructors and two
facilitators involved in the UGRU TSG was to conduct a literature review of thinking skills. One paper came to be the primary resource, Kathleen Cotton’s article entitled “Teaching Thinking Skills” [14]. This article served as background information as the group worked to establish a local definition for thinking skills as well as descriptors of student behaviors that indicate performance of thinking skills. A clear understanding of the behaviors expected of students evidencing thinking skills allowed the group to establish a set of thinking skills objectives to be incorporated into their lessons. Specific lessons were developed with clearly identified expected impacts on the students. Each lesson developed was then taught by one instructor, with a peer observer focusing on the impact of the lesson on students in terms of thinking skills. Following the teaching and observation of the lesson, the group came together to reflect on how the lesson went and revise the lesson plan. Each discussion was audio recorded and the tapes later analysed for emergent themes. Data obtained from the observations and discussions was further triangulated through focus groups held near the end of the semester to discuss the process itself. Through this process a core group of instructors became local “experts” in thinking skills and have begun to spread their understanding to other teachers through a similar process. The steps of the Lesson Study approach are summarized in Table 1.

<table>
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<tr>
<th>Step 1</th>
<th>Establish local knowledge</th>
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<tr>
<td>Step 2</td>
<td>Develop lessons with clearly identified expected impact on students</td>
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<tr>
<td>Step 3</td>
<td>One person teaches the lesson, partner observes impact on students</td>
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<tr>
<td>Step 4</td>
<td>Reflect on how the lesson went</td>
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<tr>
<td>Step 5</td>
<td>Revise the lesson plan</td>
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The products generated by the UGRU Mathematics Program Thinking Skills Group are presented in the next section. Discussion of the overall impact of this approach from the perspective of the participants is presented in section 5.

LOCAL KNOWLEDGE – THINKING SKILLS DEFINITION, INDICATORS AND OBJECTIVES

Implementing the explicit modeling of thinking skills in the mathematics classroom is a process. It is not something that happens through a series of workshops with presenters telling teachers what to do. Rather, we argue that the process should intimately involve the teachers in all phases of implementation, and this was the approach taken by the UGRU TSG. This process includes teachers identifying what thinking skills are and how they know when students are using them. This enables teachers to better pinpoint best practices for developing thinking skills in the mathematics curriculum. As Ahmed, one of the participants, pointed out, “This is not something out of nothing. It can be done.” The core of this initial phase was the realization by participants that if we want students to learn meaningfully, to think flexibly and make reasoned judgments, then we must make clear what we mean by these types of thinking and model them explicitly. As Mohamed shared, “We [teachers] should learn how to do it, so as to be also developing ourselves and our students.” In other words, teachers themselves went through the following steps:

- Sharpened their own understanding of a range of thinking skills and determined local indicators of thinking skills behavior;
- Developed an ability to readily identify contexts or topics within the curriculum which can be matched with particular thinking skills;
- Developed a vocabulary for talking about thinking which is suitable for the age and ability levels of the students in the UGRU classroom;
- Recognized the need to be explicit about the process of thinking as well as the content;
- Developed lesson plans that met both high quality thinking skills and content objectives;
Taught/observed, reflected on and revised the lessons developed.

The initial two sessions of the UGRU Thinking Skills Group (TSG) focused on identifying a group understanding of what thinking skills are, and how one knows when a student possesses them. Through consensus, the following definition of thinking skills was locally developed:

“Thinking skills are those skills which enable a person to decode information and make connections in order to reach a plausible conclusion or create new scenarios.”

This locally developed definition contains many components similar to those found in the literature. For example, most definitions of thinking skills refer to a need to “comprehend.” Locally, this has been defined as “decoding information.” Other definitions refer to “make decisions” and “synthesize many elements.” Similar components are also found in the locally developed definition. So why create our own definition? As one of the instructors put it, “The process of developing our own definition gave us a much deeper understanding than if we had just adopted someone else’s definition. This is something that we did.” This is the empowering aspect of the approach used by the UGRU Thinking Skills Group.

The next question faced by the group was to determine what it is that UGRU students do that indicates that they possess thinking skills. The literature read indicated that evidence of thinking skills involves generating and evaluating ideas, organizing information, formulating questions, drawing logical conclusions, making predictions, making decisions and supporting opinions, and solving problems. Participants were asked to pay particular attention in their classes to the behavior of their students and to write down descriptions of the behaviors that they perceived as indicative of thinking skills. The indicators thus determined are shown in Table 2.

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<thead>
<tr>
<th>Asking questions</th>
<th>Justifying solutions</th>
<th>Inferring and predicting</th>
<th>Transferring ideas</th>
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<tbody>
<tr>
<td>Seeing exceptions</td>
<td>Providing counter ex.</td>
<td>Comparing</td>
<td>Making connections</td>
</tr>
<tr>
<td>Demonstrating curiosity</td>
<td>Identifying patterns</td>
<td>Gathering information</td>
<td>Organizing information</td>
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<tr>
<td>Deducing</td>
<td>Focusing on task</td>
<td>Using strategies</td>
<td>Generalizing</td>
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<tr>
<td>Critiquing</td>
<td>Synthesizing</td>
<td>Visualizing</td>
<td>Evaluating</td>
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These indicators are similar to the habits of mind that others refer to. However, the process of identifying behaviors not from an article, but from the very students who they teach allowed the instructors to see that UGRU students are indeed capable of possessing and demonstrating thinking skills, and that while they may be labeled in ways similar to those identified by others, how Emirati students “perform” them may be different. From these indicators, participants worked in small groups to establish thinking skills learning outcomes that they could include in their own lessons. The objectives developed are as follows:

*By the end of the unit, the student will have...*

- Built an argument to justify their solution;
- Made a connection between the result and a real life scenario in order to make a decision;
- Used physical images to confirm the accuracy of the claim;
- Made a prediction using data generated;
- Reasoned beyond available information to fill in gaps;
- Asked probing questions;

Once again, the importance of this process is that the instructors now took ownership of these objectives, and were much more positive and comfortable including them in their own teaching.
The strength of this approach in terms of empowering the participants is evidenced by the comment made by Fadel at the end of the semester: “When it comes to the objectives, I don’t think it should be only a written objective, it should be part of us. Through what we have done the objectives have melted into our teaching.”

From the ideas generated in the initial meetings, weekly seminars were held for the development of the teaching materials. During these sessions, instructors applied the knowledge gained to the development of a daily lesson plan on topics to be taught sometime during the subsequent two weeks. Project tasks included peer observations that focused on specific aspects of classroom practice that the group had identified as a key place for the explicit discussion of incorporating thinking skills into student practice. These observations served as focuses of discussion regarding further materials development, and lead to revision of curricula and lesson plans. Initial discussions most often focused on the content and how thinking skills were embedded in the lesson without any recognition for the need for explicit teaching. As the group progressed, however, the tone of discussions began to move away from the content and towards concepts surrounding how the teacher models thinking skills in the lesson, and how the teacher assesses student development of the thinking skill. In other words, discussions that began with complaints about students such as “They tend to just follow a process without thinking about what to do” became “So where is the thinking skill?” and “How do you model the thinking skill in your lesson plan?” and “How do you assess student competency on the thinking skill?”

DISCUSSION – POSITIVE IMPACT

First and foremost, the aim of the UGRU Thinking Skills Group was to promote student acquisition of thinking skills. Informal and formal assessment tools administered to date provide solid evidence that the project has been successful in this regard. Students in classes taught by TSG participants score higher on exam questions requiring demonstration of thinking skills, and classroom observations reveal a much higher rate of students evidencing thinking skills behaviors than in other classrooms. Detailed analysis of student acquisition, while important, is not the focus of this paper and will be presented elsewhere [15]. Instead, we have sought to describe a professional development process that overcomes the general resistance encountered in the top-down approach to infusing thinking skills all too often employed. Whereas the programs described in the background section have met with only limited success in terms of promoting an inclusion of thinking skills modeling into content area teaching, we observed that the combination of lesson study and communities of practice approach employed by the UGRU Thinking Skills Groups has had much more powerful, long lasting impact. This is clearly revealed through analysis of the focus group discourse. Three main themes emerge from discussion with UGRU TSG participants: 1) Participants developed a clear understanding of the need to infuse their mathematics lessons with thinking skills modeling, 2) The process has had a clear impact on their teaching and led them to become much more active in their approach, and 3) Participants have established an sense of community that provides them with ongoing support.

The process used has allowed teachers to sharpen their own thinking about thinking and develop tools for more effective planning. As Abdullah shared, “I think we gained a lot as teachers. I think we now know how to do it [plan thinking skills infused lessons]. We have a clear vision about doing thinking skills within a content lecture.” The solid impact of the process of establishing a community of practice is evident in the words of Hussain, who stated that “The process opened up my eyes to some things that I didn’t do and other things that other teachers do different. That part was very good, I learned from them.” More important, the teachers expectations of students have been raised, leading to what one participant described as a classroom full of “confidence”. Students are more active and demonstrate, along with their teachers, an increased knowledge of thinking language and vocabulary. As teachers, the process of working together to define and describe thinking has given them tools that have improved their questioning strategies in the classroom and lead to more structured group work: “Now we’ve been
through all these discussions. So definitely, when we’re going to prepare our lessons next semester, we’re gonna take into account those things we’ve decided on.”

CONCLUSION

The project described in this paper represents a teacher-oriented approach to improving student thinking. The approach blends sound theory with local knowledge and effective classroom practice that is transferable to other teachers. In other words, the goal of the project was to enable instructors to embed thinking skills within curricular areas and to use naturally occurring opportunities for developing thinking within the ordinary curriculum. It is based on the idea that good thinking may have as much to do with creating a disposition to be a good thinker as it has to do with acquiring specific skills and strategies. It emphasizes the idea that students must be given the time and opportunity to talk about thinking processes, to make their own thinking more explicit, and to reflect on their strategies. That a bottom-up approach to the concept of including thinking skills in the classroom can be effective is best summed up in the words of one of the instructors who participated in this project, “I must say, looking at this or any other document that has been produced by the teachers in this group, actual teachers in the classroom, makes all of us proud that we have achieved something that early in the semester was almost impossible.”

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REFERENCES
