Annotated Bibliography of Research on Higher Order Thinking

Mark Koczij
D'Youville College
Professor S. Williams
EDU620 Theories of Learning
March 8, 2005

In Bloom's *Taxonomy of educational objectives*, we are provided with a very helpful tool for considering the range of goals and outcomes from educational experiences. The level of abstraction in the cognitive domain (as opposed to the psychomotor or affective) that emerges from these experiences range from simple *knowledge* at the lowest level ranging all the way to *evaluation*. This taxonomy provides a helpful way to discuss the issue of abstract, conceptual, or higher order thinking.

The three lowest levels of abstraction in thinking are knowledge, comprehension, and application. These are all exhibited at a very early age and continue throughout our lives. However, the higher order thinking that emerges in late childhood and early adolescence – analysis, synthesis, and evaluation – truly marks the beginning of serious consideration and contemplation. In the general area of communication/language and mediation skills, it is this phenomenon that should hold the greatest interest of teachers who hope to leave their students stronger and more prepared than when they found them – especially at as crucial a time as middle school and early high school.

Is there anything in the research on higher order thinking in the classroom that gives us clear direction on when children move from learning about basic knowledge and application to when they begin to synthesise their knowledge and evaluate the application of it; and further to that, do any strategies for encouraging this transition emerge from this research?

Bennett, J. and Kennedy, D. (2001). Practical work at the upper high school level: the evaluation of a new model of assessment. *International Journal of Science Education, 23* (1), 97-110.

This study drives home the importance of matching the assessment of skills and knowledge to their application and how a more authentic assessment is can contribute to the promotion of higher order thinking. For students graduating from the Irish public school system the Leaving Certificate examinations are the last step in the process. This study examined how paper and pencil examinations failed to properly assess practical skills in science and how an emphasis on written exams acted as a disincentive for science teachers to spend substantial time applying the knowledge and comprehension level content.

Bennett and Kennedy did a comparison of two different assessment models that were actually used in 1997 and 1998 countrywide in Ireland. The study involved the results from testing done in a total of 29 schools in chemistry and 30 schools in physics (366 and 337 private school students respectively). The first year there was no practical portion to the examination and the next year there was. This was a correlational study comparing the data from the examinations to control studies done of student's knowledge and abilities. Both assessment models were also analyzed using Bloom's full taxonomy (All cognitive levels, affective, and psychomotor). The results showed that the practical assessment not only correlated more strongly with student's previously assessed abilities, it also tapped into the higher order thinking skills where the written exam did not.

This study clearly demonstrates how Bloom's entire taxonomy must be used in both the instruction and assessment of high school students. Incorporating affective and psychomotor elements into the educational experience are key to the promotion of higher-level cognitive abilities.

Fisher, R. (2002). Shared thinking: metacognitive modelling in the literacy hour. *Reading: Literacy and Language, 36*(2), 63-67.

Metacognition is the subject of this study. Metacognition fits into the questions surrounding higher order/abstract/conceptual thinking because the mere fact that one is aware of and considering one's own thoughts is a clear demonstration that higher order thinking is happening.

Fisher addresses the problem that emerges from his study (conducted in the U.K.) which found that in 170 hours of observation of teachers reading and writing with students at the grade five level, only one single instance of metacognition was modelled for the students ("Why, do you think, did the author began the sentence with *and*?"). These 170 hours was spread out amongst 20 different teachers in a programme that was designed to get teachers discussing both what makes good reading/writing and how one gains control over the reading/writing process through careful reflection (metacognition). However, only one instance of the latter occurred, making this programme an utter failure, and Fisher considers this troubling fact an indicator of where the school system is failing students at the promotion of higher order thinking.

The major issue that the teachers reported in trying to implement a metacognitive approach to literacy learning was that they had their hands full enough with simply modeling the *how* of reading and writing, let alone opening a discussion on *how one thinks about* the how of reading and writing. Yet, the author raises the point that if one cannot model to students how teachers overcome literacy challenges, then students are truly being undereducated.

The study has a very small sample size and though the author acknowledges he could be wrong, it is not a stretch to believe that there is a profound lack of metacognitive modelling occurring at all grades. The role of literacy in abstract thinking is clear; however, Fisher takes this relationship one step further and demonstrates the importance of a literacy curriculum which strongly incorporates abstraction (through metacognition) as a basic tool for raising students' abilities in both.

Gierl, M.J. (1997). Comparing cognitive representations of test developers and students on a mathematics test with Bloom's taxonomy. *Journal of Educational Research, 91* (1), 26-32.

This study involved 30 grade 7 Catholic school students (16 boys and 14 girls) in a mathematics classroom who wrote a regular test for the unit they had just completed. The question the researcher hoped to answer was whether or not test designers can accurately predict which of the lower level cognitive processes will be used by students writing the examination.

Each question on the test was designed with one of Bloom's three lowest level cognitive processes in mind. For example, some questions were considered simple tests of knowledge and others were intended to be solved as application problems. The questions and the students' approaches to solving the questions where categorized using Bloom's taxonomy. In order to ascertain which cognitive skill was at work when solving the problem, the student was instructed to talk aloud through their answer so the researchers could follow their thinking. In addition to this, the results of the study were broken down by high and low achieving students, to see if there is a difference in the cognitive skills used by these two groups.

A number of very interesting results were found. The first was that just over half (54%) of cognitive responses reported by the students matched the cognitive levels anticipated by the test designers. The second was that test designers were better able to predict which process would be used by high achieving students than the low achieving ones. (56% match vs. 51%). Finally, comprehension tasks and strategies were most accurately matched – which does not surprise the researcher, who comments that Bloom et al. anticipated this fact when they observed that comprehension tasks make up the lion's share of educational experiences in schools.

This study clearly demonstrates that there is a rather large chasm between the intentions of teachers and the results found in students. If a teacher is unable to predict how students will answer questions on a standardized multi-choice mathematics exam (that the teacher herself designed), how could she confidently claim to know how a student will address far more complex and conceptual problems. Though the implications of this study as discussed by the researcher are limited to examination design, it reeks of something far more complex for teachers concerned about honing students' skills in higher order thinking.

Jackson, L. (2000). Increasing critical thinking skills to improve problem-solving ability in mathematics. (Master of Arts dissertation, Saint Xavier University, 2001). *Science, Mathematics, and Environmental Education.*

Mathematics is identified as the area within the curriculum where students show the greatest resistance and poorest performance in applying critical thinking. In this study, a strategy to address this problem for a grade six classroom in northern Illinois is implemented. It involves integrating critical thinking into the curriculum by allowing students to approach problems in any one of many different ways (draw a graph, use a formula, count it out, etc) as well as the introduction of journal writing, reflection on the journals, and finally cooperative learning activities.

All of the activities were explicitly aimed at giving more ownership to the students over their own math educations. This was combined with activities designed to access multiple intelligences and always with an eye on Bloom's top three cognitive educational objectives. Students were given pre and post-tests in order to measure the efficacy of the intervention. A total of 17 grade six students were the subjects in the study and, of these, nine showed a statistically significant improvement in higher order thinking skills in mathematics. But more importantly to the researcher, there was a significant improvement in the affect of many of the students, evidenced by comments in their journals of genuine self-congratulation and a rise in self-esteem. There were also improvements in the social behaviours of students arising from the cooperative learning activities.

The conclusion of this study emphasised the need for continuous training in higher order thinking and that such training must be incorporated into a programme of life long learning. Though the conclusions are rather broad, the success of the system created seems clear enough and provides teachers of more process and knowledge-based subjects (maths, sciences, and technology) with a starting point for introducing some analysis, synthesis, and evaluation in the form of metacognitive (journal reflection) and social exercises.

Mistretta, R.M. (2000). Enhancing geometric reasoning. *Adolescence, 35*(138), 365-79.

The Van Hiele model of geometric thinking skills was used as the basis for this study. This model uses a scale that moves from most concrete to most abstract style of thinking, and a detailed description of each stage is outlined in the article. The researchers were studying the effectiveness of a supplemental geometry unit designed to raise the *Van Hiele thinking levels* of 23 grade eight students in a middle school classroom. Pre and post-tests were given to assess the efficacy of this supplemental unit.

The results, to no one's surprise, were that the supplemental unit was successful in raising both the number of students that were able to achieve higher levels of conceptual thinking and the degree to which students scored within the levels they achieved (i.e., pre-supplemental unit, the student scored 72% at level 2, afterward the student scored 90% at level 2).

This supplemental unit, though primarily targeted at teaching rudimentary geometry concepts, used multiple methods to do so. Real world questions and applications were presented, students had to solve problems using their new knowledge, and both graphic and conceptual (numeric) approaches were taken in the instruction and assignments. This targeting of multiple intelligences clearly plays a very important role in raising the level of abstract or conceptual thinking employed by the students; particularly when one considers that all of this was done in a subject area that could so easily be taught with a traditional skill and drill style. It is clear that these students will be better armed for when they are called upon to seriously considered theoretical math problems.

Noble, T. (2004). Integrating the revised Bloom's taxonomy with multiple intelligences: a planning tool for curriculum differentiation. *Teachers College Record, 106* (1), 193-211.

The thrust of this study comes from the application of a planning tool designed as a combination of Gardner's multiple intelligences (MI) with a revised Bloom's taxonomy (RBT). This MI/RBT tool was created to help teachers better deliver a *differentiated curriculum* – meaning that they can successfully teach material to learners at all levels within the same classroom. The MI/RBT matrix provides sentence stems to suggest learning activities and questions that range from simple to complex thinking in each of the MIs. Teachers used the matrix to design learning outcomes and activities so that their students could demonstrate what they understood through different intellectual domains at the same or different levels of cognitive complexity

There were 16 teachers of classrooms ranging from kindergarten to grade six observed using the MI/RBT tool for 18 months. There were both qualitative and quantitative analyses conducted. The outcomes, both in terms of objective measures of student performance and the reports of the teachers experiences indicate that the use of the MI/RBT tool for unit and lesson planning created inclusive classrooms which were able to address the unique needs and abilities of the students at all elementary grade levels. The teachers overwhelmingly supported the ease with which they were able to target different student's abilities using the MI segment of the matrix; whereas, the RBT segment of the tool helped teachers target higher order thinking skills for all students at all ability levels. To use Noble's own words: "By combining both typologies in the integrated MI/Bloom model the teachers perceived the MI/Bloom matrix provided a practical structure or grid to facilitate their programming to cater for greater breadth (over the multiple intelligences) and greater depth (at different levels of thinking)."

This study is of particular interest in the context of a future case study, as it seems to provide the most detailed and successful method for improving the higher order thinking skills of students at *every* level. Teachers reported a great deal of ease in the use of the tool, and the results were very encouraging.

Stabile, C. (2001). Improving the performance of sixth-grade social studies students through exposure to Philosophy. (Ed.D. dissertation, Nova Southeastern University, 2001). *Social Studies/Social Science Education*.

This is a doctoral dissertation spanning whopping 125 pages. Much of the paper is spent describing the context for the fieldwork and the procedure used to bring Philosophy into the classroom. The study was conducted in a sixth grade world history classroom in Florida. The class had been dealing with very difficult low-level assessment (facts and events) and there were very few opportunities for taking the content knowledge to a critical level. By introducing philosophical events and concepts into the curriculum, along with providing instruction sheets to the students a balance was struck between covering content and exploring ideas.

Various pre and post-tests were conducted on both the students and the teacher. There were also opportunities made for other teachers to learn philosophical concepts and terminology for introduction into their own classrooms. Most interestingly, students were actually taught Bloom's taxonomy – thus creating a vernacular for exploring higher order thinking skills within the subject matter that was being covered. There were positive outcomes on all sides of the dissertation and a large number of strategies for improving critical discussions in social science classrooms were also presented.

The idea of incorporating the concepts and vocabulary of higher order thinking into the classroom itself – making the procedural and technical aspects of abstract thinking part of the curriculum – is a stroke of genius. Of course, not all content areas will allow for it, but a week or two spent at the beginning of a semester seems to be time very well spent.

Sultana, Q. (1997). Scholarly teaching – application of Bloom's taxonomy in Kentucky's classrooms. *Presented at the Third Annual Conference on Scholarship and Teaching (Bowling Green, KY, May 2001).*

Between 1995 and 1998, 67 student teachers (teacher interns as the article describes them, in other words, first time teaching experiences) submitted lesson plans they had created for their classrooms. These lesson plans were drawn from multiple districts in the state, from both men and women, at all grade levels (with a greater emphasis on the lower grades), and in all subject areas. The lesson objectives in the plans were analysed using Bloom's taxonomy and the result was that 77% of the lesson objectives outlined by the student teachers were aimed at the lower half of Bloom's taxonomy (knowledge, comprehension, and application) – 41% being of the type *knowledge*; whereas of the remaining 23% of lesson objectives, only 3.2% were considered of the type *evaluation*.

Not surprisingly, the conclusion made by Sultana was that Kentucky teachers were aiming too much of their instruction toward the lower end of the cognitive continuum (with almost half directed at the lowest possible level) and that in order to change this, changes to the way teachers are taught in Kentucky needed to be made. It was clear to the researchers that the teacher candidates were not being taught higher order thinking skills, whether in the context of creating lesson plans or in general.

This study is of special interest to this project if, for no other reason, that it highlights how bad things can get. Whether or not the findings here can be generalized to other school districts let alone other states or countries is not clear; however, this is an example of a simple study conducted over a long period of time (three years), state-wide and recent which clearly demonstrates that colleges sending out new teachers with limited higher order thinking skills. And if the teachers cannot demonstrate abstract thinking or creativity in their lesson planning, the question is how we can possibly hope to encourage students think beyond simple knowledge acquisition and regurgitation?

Wilson, J.M. (1999). Using words about thinking: content analyses of chemistry teachers' classroom talk. *International Journal of Science Education, 21* (10), 1067-1084.

The importance of language choice in Chemistry classrooms is the subject of this study. Specifically, Wilson examines the verbatim transcripts of four teachers over a total of 69 lessons. In particular, the researcher was interested in how often words that promote metacognitive behaviours were used. The students were in an academically oriented secondary school and were from a middle class neighbourhood. The theoretical underpinning for her work is clearly social constructivist and she leans very heavily on a Vygotskian understanding of the use of linguistic signs and tools as a social mediator.

The results from the study were that instead of using words such as "calculate, deduce, distinguish, extrapolate, graph, infer, interpret, interpolate, manipulate, plot, predict, quantify, relate, represent, simplify, substitute, and visualize" (1080), the teachers would simply say things like *work-out* or *think about* or *consider*. This more informal and vague word choice gives students very little metacognitive direction and this fact concerns the researchers most. Wilson also points out that this goes directly against the dictates of the official curriculum, which uses the more specific language of higher order thinking.

This is a very interesting piece, despite its narrow sample (four teachers in middle-class Australia), because it hits directly at the problem of modeling metacognition. If teachers are not using the language of higher order thought, how can students be expected to? Wilson hints at the likely concern of teachers about intimidating or turning of students with big words, but this is a red herring. As terms are used, they can be discussed and defined – expectations for the results of a direct metacognitive request can be outlined. Students might find this harder, but it's clearly the right way to go and Wilson echoes this belief.

Zohar, Anat, Dori, Yehudit J. (2003). Higher order thinking skills and low-achieving students: Are they mutually exclusive? *Journal of the Learning Sciences, 12* (2), 145-181.

The assumption that low-achieving students do not benefit from learning experiences designed to encourage higher order thinking skills is directly challenged by the researchers behind this gargantuan study. This article is comprised of four different studies, which attack the question of what kind of benefit can be found for low-achieving students in instruction designed to target higher order thinking skills.

The details of methodology and process for each of the studies are too much to cover here; however, all four share a number of important similarities. Each of the studies was conducted in high school science classrooms in Israel, both sexes were included, there were control and experiment groups, higher order thinking tasks were created for the students in the experimental groups to work through, and the outcome of each study was described in terms of how high vs. low-achieving students benefited from the exercise. The grade level of the students ranged from seven to 12.

All four studies shared the same result. Namely, that both high and low achieving students benefited from science and technology classrooms which emphasised higher order thinking. The researchers point out that, though all students are supposed to be taught the same material in the same way, the *hidden curriculum* does emerge in a way where we find the teacher addressing stronger students in a manner that encourages analysis, whereas weaker students are drilled on knowledge and comprehension. A very interesting limitation to the conclusions of the study was that the level of *low-achiever attrition* was so high that the positive results found in that group which substantial when compared to high-achievers to create the statistically significant results.

The real gems in this research lay in the ingenious ways that the teachers were able to incorporate higher order thinking into science and technology classrooms. The use of case studies, debates, critical assessments of publications, and ethical problems interspersed in a unit on the applications of biotechnology were all outstanding examples of teaching thinking that requires higher levels of abstraction. The very positive results for students' achievement from instruction which emphasises conceptual thinking, especially in the sciences and even on tasks which require only lower order thinking, forces teachers to give equal weight to both *what* students are thinking about and *how* they think about it.

A teacher's role in the process of developing higher order thinking skills in students is undeniable. Teachers provide a wealth of modeling behaviour to students through instructional style, choice of educational experiences designed for the students, and even the types and formats of assessment. Some common themes that emerged from the scholarship above were the importance of teaching and assessing toward multiple intelligences – with diverse learners in mind – and the impact of choices teachers make about the language and activities they use in the classroom.

The scope of the preceding annotated bibliography is slightly wider than one would hope in terms of the age of studied groups and the subject areas where the studies were conducted; however, a great wealth of insight is provided by some of the extremes found in this collection of research. And much like higher order thinking itself, all of these articles share a conceptual foundation even though they approach it from many different directions.