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Unifying K-12 Learning Processes: Integrating Curricula through Learning

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This study was designed to examine whether a set of cross-curricular learning processes could be found in the respective K-12 US national standards for math, language arts, foreign language, science, social studies, fine arts, and technology. Using a qualitative research methodology, the standards from the national associations for these content areas were narrowed to thirteen distinct learning processes consisting of both singleton and hybridizations of several learning processes. The determination of a superset of learning processes will allow researchers, curriculum developers, and teachers both in and outside the United States to better understand the relatedness of certain types of instruction, irrespective of content area; develop novel techniques regarding content integration within instruction; better develop students' capacities for 21st century learning; and develop new standards more attuned to these process standards. This investigation concludes with a call for National Learning Processes Standards.

Keywords: standards, curriculum, pedagogy, national skill standards

According to Alvin Toffler, 'The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn and relearn' (as cited by the Partnership for 21st Century Skills 2002). In an era where new technologies are produced more quickly than they can be utilized, the *ability to learn* becomes paramount. Nobel Prize winning economist Amartya Sen contends that those able to apply the capacities required in the digital age ensure themselves a place in a globalized economy and further the economic potential of their respective societies (van Dijk, 2006). Sen's work and that of others emphasize the importance of studying how new processes can be utilized in educational settings and explore solutions to issues surrounding the digital divide. Familiarity with digital divide issues is usually limited to physical access limitations, but motivational, skills, and usage divides exist as well (van Dijk, 2006) similarly restricting the learning of new technologies. To prepare students to contribute in meaningful ways to a modern society, recommendations from the Partnership for 21st Century Skills (2008) state that students should gain competence in core subjects, learn through weaving 21st Century educational themes throughout their experiences, and gain skills needed for this century. Altogether, it is difficult to argue against the notion that education must change in order to meet the needs of students in the coming decades; doing so, however, requires an expanded view of educational standards that allows for an examination of how learning occurs, not just within a discipline, but across disciplines in order to enable new types of learning and processes, including digital learning and processes, not previously applied in teaching.

The readership of K-12 subject matter standards continues to expand. Classroom teachers, curriculum developers, professional development providers, teacher educators, and policymakers all frequent these documents to glean insight into their respective concerns. Thus, no longer is it sufficient for educational standards to simply list

the skills and knowledge students must possess at various stages in learning a particular subject. Educational standards must also describe how students learn the respective content. When the process of learning is central to discussions within the standards, stakeholders can apply the standards in developing instructional experiences which will help students learn the pertinent knowledge and skills.

While some professional educational standards (*e.g.* NCTM, 2000; NRC, 1995, 2000) explicitly define learning processes within a respective field – rather than simply list skills and knowledge – far more do not. Rather, the majority of professional standards documents indicate what students should learn and leave it to the reader to infer how learning takes place and what instructional practices and learning processes facilitate learning. Altogether, there exists a great inconsistency among the styles and foci among standards documents from various fields. This inconsistency makes it difficult for educators from different fields to discuss student learning.

The researchers in this study were familiar with the national standards for mathematics and science education and became curious regarding how other national K-12 subject matter standards defined and discussed learning processes. Together, they decided to investigate all current standards for K-12 education. The initial fundamental questions in mind were in reference to whether there was a common set of learning processes within all K-12 standards, whether there were more learning processes than those depicted by mathematics and science education standards, and what a cataloging of all standards would reveal. These questions led to the meta-analysis discussed herein.

Defining and Discovering Process Standards

The National Council of Teachers of Mathematics (2000: 30) states that the process standards 'highlight ways of acquiring and using content knowledge'. These processes include: *problem-solving*, *reasoning and proof*, *communications*, *connections*, and *representations*. Thus, the process standards have two interrelated foci: they define the modalities through which students learn mathematics and they define how mathematics is done by anyone with any level of mathematical understanding. Additionally, these process standards can be recognized as both tools and goals for learning. For instance, while students are to learn content and concepts more deeply through *communication* with other students, a common goal for education is for students to become effective communicators.

All other K-12 content areas have their inherent process standards, albeit many are not denoted as such. Nevertheless, experts in the learning of each K-12 subject recognize that there are modalities through which their respective subject is learned and done. For instance, although the *National Science Education Standards* (1996) and *Inquiry and the National Science Education Standards* (NRC, 2000) do not employ the term 'process standards', it is recognized that students learn and do science through a process of '5Es': *engage*, *explore*, *explain*, *elaborate*, and *evaluate*.

In most K-12 content areas, the representative standards are more content- (or product-) than process-oriented and state what a student should know and be able to accomplish in each grade. These standards are more consistent with NCTM's content standards (NCTM, 2000) which define content goals for each grade. While these content standards do not constitute process standards, the vast number of these standards in each subject area often tacitly connotes a body of process standards.

Translating from Product Standards to Process Standards

Significant difficulty exists in translating content standards into process standards. The verb choices alone within the content standards (*e.g.* describe, demonstrate, apply, compare, and etc.) are generally insufficient for reinterpreting content standards into learning processes. Often, a verb in a product statement is used repeatedly in very different contexts, synonymous verbs are used in similar contexts, and synonymous verbs are used in different contexts. For instance, depending on the context, the verb *demonstrate* can mean 'show examples', 'do a physical action', 'show an idea using a different modality', or 'give an explanation for'. Thus, the examination of product standards necessitates investigating verb use in the context of each individual standard and comparing/contrasting such with other verb choices and contexts.

Notably, the subject matter from which a product standard is found is rarely a significant factor in the reinterpretation of the product standard to a process standard. For instance, *creating* a piece of music, a written report, or an argument in support of a position are all very different activities in respect to the subject matter. However, the act of creating has many commonalities among all subject areas.

Altogether, translating from content statements to process standards necessitates a continual consideration of entire content statements both in isolation and in tandem with other statements within that subject matter area. Verbs and their synonyms must also be compared and contrasted within the context of the subject matter and beyond to other subject matter areas. This process is nonlinear and often necessitates investigating concepts and reinvestigating the concept in another context.

The Value of Investigating Process Standards

Since process standards define the processes through which students learn, amassing and categorizing as many of them as possible should be beneficial to all educators. As depicted in Figure 1, it may be possible to find valuable and appropriate learning processes which are not previously discussed in a subject matter's representative standards, or learning processes. For instance, the more broad it may be possible to define a fuller understanding of investigation of process standards may lead to discovering mathematical learning processes appropriate for other subject matters and learning processes from other subject matters previously unrecognized by mathematics

educators. Alternately, better understanding the processes used across content areas allows for the development of pedagogy for teaching 21st century curricula and for the possibility of applying pedagogy to previously undeveloped or less valued curricula, such as those enabling digital learning. More fully understanding all learning processes may better lead to understanding learning in each subject and learning altogether. This has the possibility of leading to new findings and curricular notions which can make future curriculum and instruction more effective.

Research Questions

The following questions directed this investigation and its research methodology:

1. Can process standards for a subject matter be determined when only content standards are provided?
2. Is there a superset of process standards which can be developed from all K-12 subject area standards?
3. Is the superset of all process standards larger than the set of process standards found in mathematics and science?
4. Will the superset of process standards connote that some process standards are missing from mathematics and science?

Research Methodology

In this study, the researchers began with the NCTM process standards and the 5Es of the science standards as an initial list of possible process standards. The researchers wondered whether analysis of all other K-12 subject areas would generate process standards not already listed through mathematics and science or if some of these standards could be collapsed into fewer standards. To investigate such, this study examined textual sources from a number of disparate academic fields. While some of these academic fields shared common vocabulary, they often did so with differentiated meaning attached. Conversely, any number of academic fields often employed dissimilar vocabularies to denote similar meaning. It was therefore necessary to contextually analyze vocabulary in each field. Techniques associated with discourse analysis proved valuable in this endeavor (Gee, 2005; Johnstone, 2002; Schiffrin, Tannen, & Hamilton, 2001). More specifically, this study opted for a research methodology more in line with semantic discourse analysis as discussed by van Dijk (1985). Within any literature-based research, it is necessary to delimit which documents will be examined. In the process of the research design, it was determined to use US K-12 subject matter standards documents exclusively, since these documents are published under the auspices of the national content area organizations and connote the understanding and acceptance of numerous scholars regarding the teaching and learning of those subjects. This decision was not intended to diminish the value or contribution of innumerable national and international scholarly resources which could shed more light on this investigation. Rather, this investigation was envisioned as only an initial venture to later be supplemented by further research utilizing additional resources. Altogether, the texts selected simultaneously provide a voice for each subject matter standard for K-12 education in the USA and sufficiently limit this initial study to a manageable form.

To study the standards from all the K-12 content areas and to ensure validity within the findings, three researchers worked both independently and collaboratively

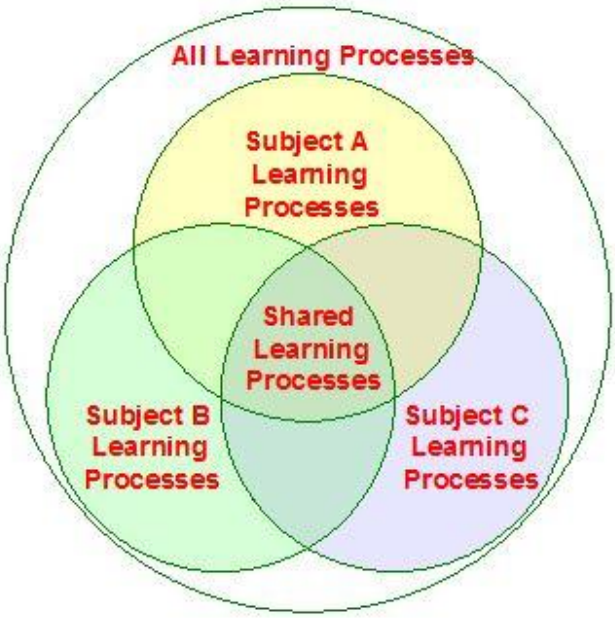

Figure 1. Learning processes are interrelated and often new learning processes are formed in areas where one or many processes overlap

to qualitatively analyze all the standards provided in the subject areas of: mathematics (National Council of Teachers of Mathematics, 2000), science (NRC, 1995, 2000), language arts (National Council of Teachers of English, 1996), social studies (National Council for the Social Studies, 1994), foreign language (American Council on the Teaching of Foreign Languages, 1996), technology (International Society for Technology in Education, 2007), and fine arts (National Art Education Association, 1994). Since textual discourse analysis involves the interpretation of various written documents and interpretation can be subjectively affected by the experiences and ideology of the interpreter, methods were included to ensure that: interpretations were true to the documents investigated; analyses of these documents were prevented from being prejudiced and self-fulfilling in respect to the researchers' backgrounds; and pertinent explicit and implicit salient points were discovered from the texts. To accomplish this and avoid prejudicing the interpretation of the documents, the researchers involved specialized in numerous distinct fields of educational research and expertise. Although it is recognized that discourse analysis is by nature subjective, it was the hope that this selection of researchers together with the following methodologies undertaken assisted in making the interpretation of the inspected documents somewhat more valid and reliable.

The following stages define the process through which this analysis was completed. (1) It was decided that all participating researchers were to be involved in all aspects of the reading, amassing, interpreting, recasting, analyzing, organizing, synthesizing, and evaluating of all documents and the respective learning standards from such. This would make the cumulative interpretation of, and subsequent work with, the text more consistent. (2) All standards documents were initially read independently by all participating researchers, thus providing the initial uncritical reading recommended by Huckin (1997). The entire team of researchers then completed all following tasks collaboratively. (3) The researchers reinvestigated all documents looking for specific learning standards, fulfilling the deeper secondary reading recommended by Price (2002). (4) Learning standards from all content areas were recorded on index cards color coded by content area. (5) Since only some learning standards were originally written as learning processes, the researchers had to return to the respective texts, consider each text holistically, and recast certain learning standards into learning processes (a process similar to that recommended by Huckin). Content standards were investigated contextually within the framework of the respective subject area in order to ascertain tacit learning processes. Key verbs from each standard were analyzed to find both commonalities and differences among processes. To enhance reliability and validity, verbs from each standard were not removed from the context of their respective statements. Thus, the verbs retained their original contextual intent. In so doing, most verbs were recognized in multiple process standards. (6) Additional comments from the recasting were added to the original index cards. In so doing, researchers were able to have continually before them the original text as well as the mutually agreed upon interpretation of such—a form more usable by this investigation. (7) Each index card was then affixed to a large, open wall. Each index card was thereby movable. As more index cards were added to the wall near cards with similar processes, conceptual themes coalesced, denoting learning processes. (8) As index cards were placed and reorganized, their positions were determined in respect to the intent of the verb in the context of the standards and not abstracted from such. (9) After index cards denoting similar process standards were associated, verbs were collected for each process standard and standards were reevaluated to ensure correct interpretation. Since, however, there were numerous synonymous verbs, synonyms were collapsed into fewer words. Then the remaining verbs were again investigated to ensure that no alteration of meaning ensued from this condensation. (10) Once the researchers narrowed the original field of content standards down to several process verbs, the categories were entered into a computer program and diagrammed to discover and denote the relationships among the terms. Once the relationships were determined, the software allowed the researchers to move the terms about on the diagrammatic grid until connections evolved and were recognized. (11) After accomplishing this, additional relationships among the terms were determined and the remaining terms were backward mapped to the processes standards previously discovered. (12) Writing emanated from these diagrams and allowed the researchers to discuss the relationships among the processes derived from the original set of standards.

Altogether, the research team chose this methodology with the belief that, in a collaborative interpretive effort, the team would provide more consistent and unbiased readings and interpretations of the respective texts and allow the texts to speak for themselves and articulate the meanings of the original writers rather than take on the beliefs of the researchers. Therefore, while discourse analysis can often be accomplished by one investigator, in this case we believed that the collaborative effort would provide deeper insights into the texts and more validity and reliability to the results of this study.

Findings

Prior to specifically addressing learning processes, the researchers made some more general findings regarding the K-12 educational standards from all academic fields which warrant brief discussion. These general observations make no judgment regarding the quality of any of the standards documents. Rather, observations are made regarding the framework of standards without evaluating the quality of the contents within the standards.

Standards from various fields can be characterized more by dissimilarities than similarities. The most apparent distinction among the standards documents may be in the

realm of the intended audience. While some subject matter standards seem to focus on the classroom teacher as the primary readers, others address the concerns of curriculum developers or policymakers. Clearly the intended audience affects the purpose, content, and style of the documents.

While some standards documents carefully define and differentiate educational principles and goals from content and process standards, others treat most of these issues alike. In the latter case, it is often difficult to determine if the goals of education go beyond simply learning the subject matter content; the role of the student in culture and society is only minimally addressed. The value of the content and purpose for its study is often disconnected from preparing students for life and success in social and career endeavors.

Some subject matter standards documents focus more on providing lists of grade-appropriate facts and skills which students must master, while others concentrate on how students learn the content. In the former, the authors of the standards seemingly believe that the readers will either possess their own understanding of how students learn or will be able to infer some of this understanding from the lists of content. In the latter cases, the standards authors seemingly believe that teachers and curriculum developers will recognize grade-appropriate content when they understand how students learn.

Many of the standards documents focus more on how instruction should take place rather than how students learn. In these cases, the reader is left to interpret how teaching recommendations are to be translated into understandings of how students learn. Thus, within the document, pedagogy is not sufficiently connected to epistemological beliefs.

Significant differences exist between the levels of specificity among the recommended content in different standards documents. While some standards denote global conceptual themes, others detail micro-concepts and specific facts which must be mastered.

The following discussions will align with the previously listed research questions. Each will be developed in its own section of varying length.

Discovering Process Standards

The first research question asked if process standards for a subject matter could be determined when only content standards are provided within the document.

While the answer to this question is in the affirmative, this was found to be so only through extensive analysis of each statement in the respective national educational standards for K-12 subjects. Notably, as previously mentioned, many subject matter standards were not written with the goal of defining the processes through which a student learns. Many subject matter standards documents focus either on grade-appropriate concepts and topics which should be covered through instruction or on the actual practice of classroom instruction and not on learning. Altogether, these dynamics forced the researchers to read, interpret, analyze, reinterpret, and synthesize process standards from statements not necessarily intended to connote such understanding.

It was particularly difficult to analyze standards in order to discover learning processes which were not explicitly stated. In the case of some subject matter standards, precise meanings of some statements, in respect to the statements being recast into learning processes, were not possible until all recommendations within that subject matter were investigated simultaneously. Only then could seminal meanings emerge which remained consistent with the intent of the document. Thus, in some cases, dozens of statements had to be understood both independently and corporately in order to deduce tacit meanings which were consistent with the whole. Nevertheless, despite the difficulties of traversing numerous documents of varying subject matter content and style of exposition, it was found possible to distill from them clearly defined learning processes.

Categorizing Process Standards

The next two research questions inquired whether a superset of learning processes could be developed from all K-12 subject area standards and if this superset would be larger than the set of process standards found in mathematics and science. As demonstrated herein, both of these questions are also answered in the affirmative.

After learning processes were gleaned from one subject matter, this procedure was repeated for all others. In so doing, a cadre of learning processes was recognized.

However, the initial list of learning processes was too lengthy to be either meaningful or useful. After further analysis, it was determined that many of the learning processes shared sufficient characteristics to be considered synonymous. This led to another level of analysis aimed at determining if synonymous learning processes could be collapsed into fewer learning processes. It was found that this was possible.

Immediately, *explore* from science and *problem-solving* from mathematics were recognized as adequately synonymous to justify connecting the two processes. As analysis continued, additional themes of processes emerged.

Thirteen distinct process standards were discovered among all of the standards within all the K-12 subject matter documents. These included:

1. The original nine combined mathematics and science standards:
   a. Math and science combined: *problem-solving* and *explore*;
   b. Math: *Reasoning and proof*, *Communications*, *Connections*, and *Representations*;
2. Science: *Engage*, *Explain*, *Elaborate*, and *Evaluate*; Three new hybrid learning processes: *Relation*, *Justification*, and *Profession*; and
3. A disconnected standard denoted *Skills & Practice*.

Each of these process standards, as found in standards documents, is denoted and defined in Figure 2.

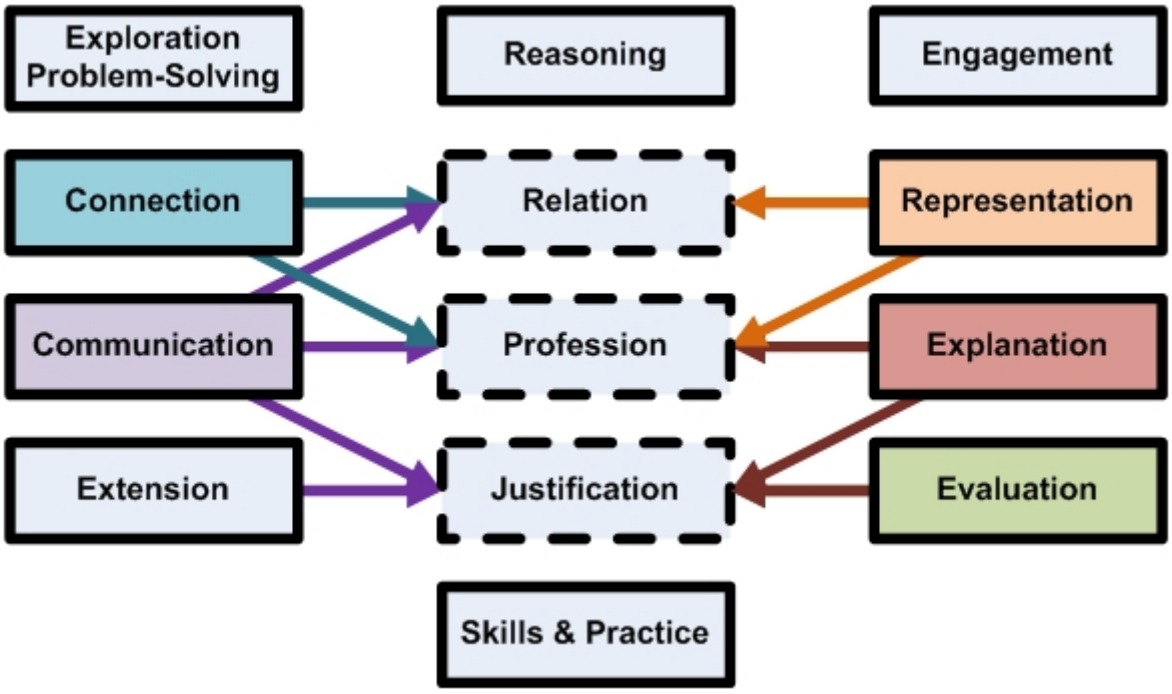

Figure 2. Process standards that emerged from the categorical mapping exercise.

The following thirteen process standards are divided into two groups: singletons and hybrids. While singleton learning processes can be defined in one camp, hybrid learning processes share many commonalities with listed singletons. However, in numerous dimensions, it can be stated of hybrid learning processes that 'the whole is greater than the sum of its parts'.

The following descriptions will attempt to develop the distinctiveness of the hybrid processes from its constituent parts. Further discussions of some of these listed processes follow.

Singleton Learning Processes

Skills and practice. Numerous K-12 subject matter standards indicate that the practicing of skills, techniques, and algorithms has a definite place in student learning and that students learn as they repeatedly do some tasks. Verbs from various product and process standards which are commonly employed in this discussion include: work (independently and cooperatively); calculate; estimate; distinguish; differentiate; identify; practice; perform; and read (various representations in the respective subject matter). For this research project, this list of verbs has been codified to: contrast/differentiate/distinguish; identify; collaborate; calculate; estimate; practice; and perform.

Notably, within subject matter standards promoting the importance of *skills* and *practice*, these processes are neither divorced from deepening conceptual understanding nor imply the historic convention of *drill and kill*. Rather, as in the learning of music, *skills* and *practice* are seen as necessary components of mastery leading to deeper understanding of more sophisticated musical concepts. Thus, *skills* and *practice* are simply necessary components to conceptual understanding of music.

While a significant number of subject areas contain standards statements which fall under the process standard *skills & practice*, these statements are usually qualitatively different from all others. Most significantly, these standards statements often demonstrate greatest value for the content being learned more so than for the process of learning, the value of such knowledge for the growth of the student, or the connection of that factual knowledge with other facts and understanding. Most often, when a subject matter's standards consist primarily of grade-appropriate lists of topics, concepts, and skills, which are to be mastered, the focus of the document's authors seems to

be in respect to this process standard. However, this description is not intended to ring pejoratively. Rather, those who promote *skills* and *practice* do so because they seem to truly believe that learning occurs through such.

Exploration/problem-solving. This learning process is usually defined as students learning as they investigate novel concepts or find themselves in a situation in which they do not know how to navigate. As students experience problem scenarios, they learn the pertinent concepts, how to solve that type of problem, and how to solve other problems. While leading a student to the skill of problem-solving is a goal of most educational efforts, it is also recognized that the process of *problem-solving* itself leads to different and greater learning. Within product and process standards, the verbs most commonly seen are: think; plan; research; investigate; explore (causes and consequences); organize; develop multiple interpretations; justify selections; and seek reasonable solutions. This process was collapsed to the fewer verbs: interpret/explain; organize; and investigate.

Reasoning. While it is the role of education to grow students to become reasoning agents and to be able to reason through complex tasks as adults, this standard also argues that students learn through the process of reasoning; they both learn to reason and learn more deeply about the topics through which they are reasoning. *Reasoning* may be either formal as in mathematical proofs, debates, or expository writing or informal as in extemporaneous classroom discussions. The collected verbs leading toward *reasoning* include: analyze; evaluate; describe; identify; compare/contrast; explain; recognize and interpret. These are herein codified to: interpret/explain; describe; contrast/differentiate/distinguish; compare/connect/correlate; identify; analyze; evaluate/critique/assess/defend; and organize.

Connection. This learning process can be defined as determining and/or applying relationships between and among concepts and representations. Connections can be formed internally among topics within a subject matter or externally applied from one subject matter to another. (For instance, an algebraic concept can be seen geometrically or the same algebraic concept can be applied to music.) From the product and process standards which spoke to *connection*, the verbs most commonly employed are: locate; assess; organize; synthesize; evaluate; apply information; and evaluate multiple points of view. In this investigation, these and numerous other terms were collapsed to the verb list: compare/correlate; apply; organize; evaluate/critique/assess/defend; and synthesize. Several types of specific connections were commonly found in the standards and these include: connections from content to content, connections from content to culture, and connections from content to person.

Communication. This learning process can be defined as the mono-directional (speaking to), multi-directional (sharing among), mono-modal (writing), and multi-modal (presenting orally and with charts) dissemination of information. While *communication* may include a student producing oration and writing, it may also include a student learning through listening to others and reading what others have produced. Additionally, it may take innumerable content-centric forms including dance, music, poetry, and expository writing, among many others. From product and process standards discussing this element, the verbs most commonly used are: collaborate; demonstrate; articulate; give examples; engage in conversations; provide and obtain information; express feelings and emotions; exchange opinions; write; depict through visual language; and tell stories. These and other terms were collapsed to the verb list: demonstrate/show examples and collaborate.

Some standards documents emphasize different contexts for *communication*. Standards often recommend teacher and student communication being attuned to and appropriate for different purposes, audiences, and contexts. Thus, effective *communication* skills allow a student to effectively share ideas in many environments. Other documents emphasize that the value for students to become effective communicators resides more so in students being able to communicate and gain employment outside of school in a broader social environment. Verbs most often associated with *communication* include: demonstrate; show examples or evidence; give/share information/ideas/reasoning; justify; and convey/articulate.

Explanation. Although closely connected with the more general and global notion of *communication*, this learning process usually connotes a more specific process of analyzing information and confirming findings to oneself or to others. Verbs from various standards which are generally associated with this process are: give examples; describe; identify; interpret; distinguish. This process was conceptualized around the verbs: interpret; describe; identify; contrast/differentiate/distinguish; and demonstrate/ show examples.

Extension. This learning process speaks to expanding concepts either to or through additional concepts or by applying concepts to other realms. While *connection* seeks to "determine relationships between and among concepts and representations," *extension* purposely seeks to take these connections in novel directions. Verbs often associated with this learning process include: apply; expand; solidify; construct; describe; explain; by demonstration; formulate strategies; make suggestions; reconstruct and reinterpret; convey; and design. These verbs were simplified to: interpret/explain; describe; demonstrate/show examples; apply; and construct/create.

Representation. Nearly every idea can be represented through multiple modalities. For instance: emotions can be represented through actions, poetry, or music; equality can be represented geometrically, algebraically, or philosophically; and part-whole relationships can be represented numerically or through subcultures and cultures. Within mathematics, four representations are commonly

recognized: verbal, numeric (or tabular), symbolic (or algebraic), and graphical. The learning process of *representation* connotes students interpreting various forms of conceptual representations, independently recreating conceptual representations, and translating from one representational form to another. Educational standards connect *representation* with the verbs: improvise and compose (music); conceive and create; compare and contrast (forms); illustrate (ideas); read/interpret/apply (appropriate diagrams and data); show (through examples using technology); and make mental maps. This investigation coalesces These verbs to: interpret/explain; contrast /differentiate/distinguish; compare/connect /correlate; construct/create; and illustrate.

Two foci of *representation* are commonly seen in educational standards from the humanities and social sciences. The interworking among society, culture, and subcultures is regularly treated as a *representation* of various social dynamics and concepts which, although occasionally esoteric, are important for students to learn. The person, as an individual participating within society, is also regularly developed as a representation for students to understand concepts such as freedom, human value, and responsibility. Together, both culture and the person become common, educationally valuable representations.

While it may appear that *representation* and *communication* are synonymous processes, important distinctions exist between the two. Although connections can exist between different representations of a concept, concepts can also be interconnected without use of different representations. Second, any representation of a concept can be utilized without consideration of other concepts or representations to which it may connect.

Evaluation. Students learn as they analyze and evaluate concepts and ideas. Using theoretical arguments or experimentation, the process of evaluating concepts for truthfulness or validity leads to greater understanding. *Evaluation* differs from *reasoning* as *evaluation* speaks to the specific purpose of determining truthfulness/value and *reasoning* addresses the more global dimension of thinking through ideas with or without the necessary concern for truthfulness. Verbs which commonly express these ideas include: describe; analyze; compare/contrast; evaluate; identify; recognize; interpret; describe (the role); formulate; examine; investigate; consider; observe; speculate; construct reasoned judgments; apply; articulate; justify; critique; evolve (criteria for evaluations); describe (meaning of representations); reflect analytically; correlate; defend validity; and form and defend judgments. This study abbreviates this list to: interpret/explain; describe; contrast/ differentiate/distinguish; compare/connect/correlate; identify; analyze; apply; critique/assess/defend; investigate; reflect; and speculate.

Engagement. Students learn as they become personally involved in the subject matter and they see the relevance of the topic to their own lives. Sharing similarities with *connections*, *engagement* relates connectedness of the subject matter to the students and vice versa and not simply one topic to another. Although *engagement* speaks more to the affective domain, the subject matter standards which promote *engagement* recognize that learning is more effective and efficient when students are interested in investigations and recognize the pertinence of such for their lives. Common verbs surrounding this learning process include: participate; reflect; create; and show evidence. Herein, these are simplified to: construct/create and reflect.

Hybrid Learning Processes

Justification. While *justification* is the intersection of *evaluation*, *communication*, and *explanation*, it transcends these three singleton processes through the purpose it places on the process. This standard argues that students learn more about a topic as they communicate and explain their evaluation of work or a product (either their own work or the work of others) associated with the topic. While *evaluation*, *explanation*, and *communication* each have role in the process of learning, the subject matter standards documents seem to state that an additional dimension of learning occurs when these three processes are purposively interwoven. The most common verbs associated with this learning process are: analyze; explain; describe; differentiate; interpret; and examine. Herein, these have been solidified to the verbs: interpret; describe; contrast/differentiate/distinguish; demonstrate/show examples; and analyze.

Relation. While it is possible for *connections* to consider the interrelatedness of various representations of a concept and *representations* to simultaneously consider more than one representation, *relations* makes the investigation, integration, and application of various distinct representations of a concept the specific goals of the process. In mathematics, this is tantamount to considering representations singularly versus considering multiple representations simultaneously. This learning process proposes that students experience a different, and possibly deeper, dimension of learning when they investigate concepts through simultaneous multiple representations. Common verbs used in this discussion include: describe and examine relationships; reinforce and further knowledge; compare different representations; and recognize the distinctiveness of representations. Herein, these verbs are abbreviated to: describe; and compare/connect/correlate.

Profession. Although interconnected with *representation*, *communication*, *connection*, and *explanation*, *profession* transcends all of its constituent parts. *Profession* is the process of a student experiencing and communicating in a field of study in a manner consistent with professionals and experts in that field. Although this dimension of communication and experience is possible within and among a number of previously listed singleton and hybrid processes, this process standard has the stated goal of students doing, experiencing, and communicating about a concept in a manner consistent with

professionals (albeit at an age-appropriate level of understanding and sophistication). This standard promotes the notion that learning differs and is enhanced when educational experiences are modeled by or situated within professional practice. Verbs commonly used to construct this learning process include: analyze; compare; create; demonstrate; apply technology to synthesize information and communicate knowledge; give examples; describe; connect concepts in one field to concepts in another; identify and describe patterns; apply concepts; and illustrate. The investigators of this study have recast this list to: interpret/explain; describe; compare /connect/ correlate; identify; demonstrate/show examples; analyze; apply; construct/create; synthesize; and illustrate. These leaning processes, together with their included key verbs, are presented in Figure 3.

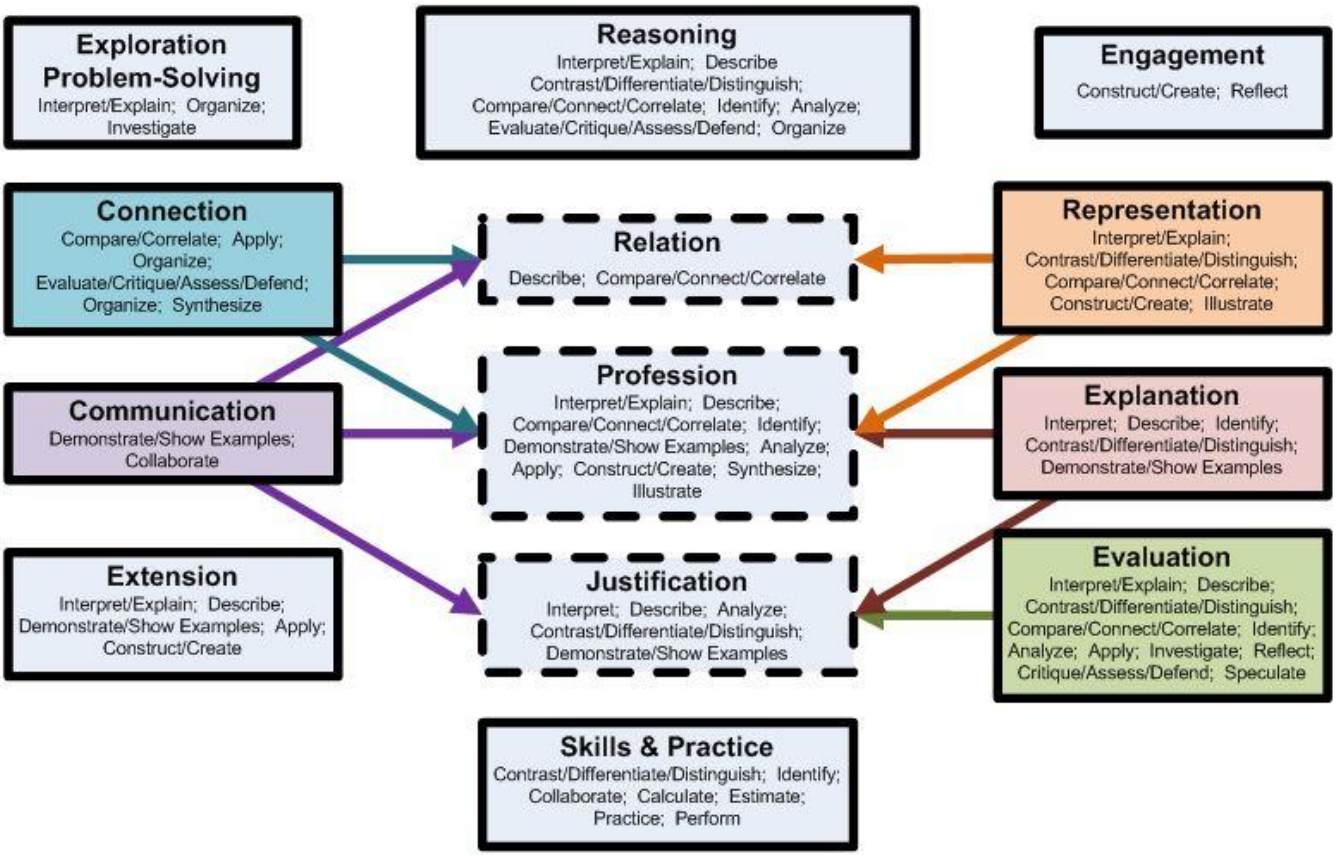

Figure 3. Cross-curricular process standards and the relationships among them.

Discussion

This study sought to conclude whether a superset of learning processes could be determined from the US national K-12 content standards provided in individual subject areas. It also sought to determine whether processes aside from those identified in the math and science standards would emerge. Having determined that a set of thirteen learning processes could be identified from the subject area content standards, a set which transcends those provided by the math and science standards, the researchers have determined that a larger map now exists to use in the discussion, creation, and analysis of curriculum.

The identification of the learning processes that underlie the K-12 national content standards has the potential to greatly influence future directions in education. These findings have implications for stakeholders including curriculum and standards developers, teachers, and teacher educators. Knowing that thirteen overall learning processes encompass the entire set of standards might enable these individuals to put a greater emphasis on the processes used in teaching content and develop methods for teaching content or subject areas that have been previously non-existent or underdeveloped (*e.g.*, digital learning skills). An extensive discussion of the possible applications of all learning processes is beyond the scope of this article, but brief discussion of these learning processes, as well as implications and possible future directions for this research, is provided.

The Existence of Thirteen Learning Processes

The fact that all K-12 subject matter standards could be analyzed and synthesized into only thirteen distinct learning processes is far from trivial. This finding alone leads to a number of significant implications.

First, it can be said that learning across almost all fields does not differ as greatly as some might be prone to assume. Learning a foreign language may not differ all that greatly from learning science or fine arts. If this is the case, and a thorough understanding of learning can be accomplished through the understanding of only thirteen learning processes across all subject matters, educators and curriculum developers have greater opportunity to create epistemologically sound and consistent curricular materials across all disciplines.

Second, the fact that the number of learning processes is manageable and that the whole superset of processes is comprehensible leads to the understanding that teachers can use the learning processes in their instructional preparation. With the learning processes as their focus, they can concentrate on teaching the student rather than the content area. Arguably, students fail to learn when they experience instruction that is not supported by epistemological understanding and sound pedagogical practice and students cannot fail to learn when instruction is directed specifically at their learning of the content at hand.

Third, the superset of thirteen learning processes may argue for the increased need for instruction, which integrates various content areas. With the simultaneous recognition that all learning occurs through combinations of the thirteen learning processes and that learning of most subject matter is more similar than different, it becomes more difficult to argue that all subject matter instruction and learning should be experienced disjointedly. In the future, if the superset of thirteen learning processes became the basis of the national standards, curriculum could be reconceptualized so that teachers taught processes rather than content areas. Instead of going to a history class, students might spend one or more periods per day in a completely integrated 'Connection Class'. In this class, students and teachers would learn how to make connections among various pieces of information and together would transcend the formal boundaries of school subject content areas to learn to make meaning through multi-dimensional processes. However, since it is highly unlikely for the educational system to reorganize the curriculum according to learning processes rather than content areas, teachers and developers of standards might instead be yet persuaded to shift their focus from fact-based content to learning processes when creating lessons and units.

The identification of these thirteen learning processes raises some important issues. Answering one of the research questions associated with this investigation, the thirteen learning processes certainly exceed the five mentioned in the NCTM Principles and Standards for School Mathematics (2000) and the 5Es from the National Science Education Standards (1995, 2000). Another way of stating this may be that the standards document for mathematics has missed some learning processes through which mathematics could be learned.

Hybrid Learning Processes

One possible benefit of this new superset of standards is the discovery of new hybrid learning processes. These hybrid standards, created by the intersection of several singleton standards, may connote new instructional methodologies and learning processes that could be utilized by educators of all subject areas to teach students to think about and learn content in new ways. Alternately, determining the relationship among all content processes may enable educators to develop thematic units based on shared processes and topics that span several content areas.

Since the three hybrid learning processes include components of other singleton learning processes, it may be easier for teachers to concentrate on fewer learning processes and still hit the majority of the others. For instance, rather than considering all thirteen learning processes, educators could concentrate on an abbreviated list of only eight learning processes including: *Problem-solving*, *Reasoning*, *Engagement*, *Extension*, *Skills & Practice*, *Relation*, *Justification*, and *Profession*. Since this list includes the hybrid learning processes, it also includes some characteristics of the entire superset. Some educators and curriculum developers may find this list of only eight learning processes a more manageable list from which to

create curriculum and learning experiences, and more streamlined and facilitating of the development of integrated instructional opportunities.

The hybridization of *Connection*, *Communication*, and *Representation* to form *Relation* creates a learning process that emphasizes the ability to communicate information to others in ways that enhance our understanding of one another and may potentially be useful in various content areas. In the social studies, the process of relating to one another is important as we teach young children how to become peacemakers to solve their own problems or as we teach high school students how to compare and connect the lives of people far removed from them to their own. These are both important skills and using the newly formed process of *Relation* may enhance teachers' capability of teaching these and other concepts.

Another previously unrecognized process may hold the ability to reach students. The process of *Justification* is formed at the crossroads of *Communication*, *Explanation*, and *Evaluation* and requires students to first evaluate information, and then be able to communicate the results. Thus, *Justification* is a combination of several of the singleton processes that requires a richer, more multi-dimensional process. A math student who has just used an alternate algorithm to solve a difficult math problem may be asked to create a math journal response to *justify* why her problem-solving method was more effective than another. In studying a post-Civil War era novel, another student may be asked to provide *justification* for the behavior of a sharecropper who steals from the land owner. These tasks require the learner to evaluate the information at hand and develop an explanation that can be clearly communicated to the listener. Such processes are clearly more rigorous in nature than each of the singular components within.

Finally, the newly formed *Profession* involves the combination of *Connection, Communication, Representation,* and *Explanation*. This comprehensive process requires that students activate skill sets and higher-order thinking to become knowledge producers, rather than knowledge consumers. Utilizing the process of *Profession*, a student might develop and share a previously unrecognized method of solving a mathematical proof. In another area, a student might develop a presentation to share his analysis of the similarities of two characters from the novels of Shakespeare. With seemingly different content, both students have effectively used the process of *Profession* to produce and display knowledge.

Implications According to Audience

The implications for the discovery of a superset of thirteen learning processes among all K-12 subject matter standards are numerous for all involved in education. However, individuals in certain professions within education may have more specific concerns. The following paragraphs consider the implications for standards developers, curriculum developers, teachers, and teacher educators. Each of these is considered independently.

Standards developers. Those who develop standards, either at the national or the state level, have a great deal of influence on future directions in education. If these individuals were to shift their focus to the processes involved in learning, modifications could be made to existing content standards in social studies, language arts, and fine arts, to provide greater influence of the processes involved, as is currently done in the science and math standards. The existence of a broad cross-curricular set of learning process standards, as is suggested in this article, would allow for all national K-12 standards to be mapped onto the same set of learning processes. Such a mapping would enable teachers and other developers of curriculum to observe the interrelatedness of seemingly non-related content, according to the shared learning processes. At some point, national standards should be written either entirely as learning process standards, or mapped as process standards in coordination with content standards so that teachers can more easily observe the relationships between content and process.

Curriculum developers. Curriculum developers need to place an emphasis on learning processes when writing curriculum. As they translate standards into lesson plans and units, they must retain the level of rigor present in the standards. Curriculum developers without a strong sense of the learning processes underlying the content will have difficulty constructing curriculum that meets the level of rigor demanded by the standards. If a set of K-12 national process standards existed, however, curriculum could be written to meet any of the thirteen standards regardless of content area. Also, the desired rigor could be retained due to the fact that the language of the learning processes would be stated explicitly in the standards, rather than implicitly hidden beneath the content.

Teachers. Educators should familiarize themselves with the thirteen learning process standards in order to determine how they might be used to further students' understanding of content. Teachers should also utilize the expanded process map to determine how the processes can be used to relate seemingly unrelated content. For example, the same process – *Representation* – could be used to show mathematical equality, such as in algebraic expression, or to represent human feeling, as with poetry. Though the content is different, the underlying learning process is the same. Most teachers do not illustrate these connections in their daily teaching, but may be able to enhance student understanding by doing so.

Curriculum delivery, then, should include all of the thirteen learning processes. It should be noted that there is a great range of processes from the more teacher-led *(Skills & Practice)* to the more student-led (*Exploration/Problem-Solving).* The availability of a wider range of learning processes should provide teachers with multiple pathways for increasing student understanding of content.

Teacher educators. Teacher educators must also be familiar with the learning processes that underlie curriculum as they instruct pre-service and in-service teachers in the development of curricular materials and instruction. If standards were based primarily on learning processes, rather than content standards, a greater focus would be brought to the pedagogy of teaching and would perhaps minimize the occurrence of tedious lectures based only on content coverage with little regard to instructional method. The shift in focus would require that teacher educators prepare teachers to create complex and integrated curricula including advanced applications of learning processes in the classroom.

A Call for National/International Standards on Learning Processes

While the following section maps out some future considerations for the findings in this investigation, the authors opine that the findings previously cited warrant a call for national/international standards on learning processes which would be referred to by all K-12 subject matter standards. This document could significantly help ameliorate the current set of national subject matter standards and make such documents somewhat more consistent in form and function. As previously mentioned, current standards documents differ greatly in many dimensions. Indeed, these differences are often so great as to hinder, rather than promote, collaboration between educators from different fields of study and hamper efforts toward integrated curricula across numerous content areas.

Additionally, national/international standards of learning processes could create a unique dimension of discourse in which all educators could participate. Central to the documents would be agreements regarding how all students learn and instructional techniques designed to promote such. As learning processes, these statements would discuss both the process and product of learning as defined in the opening of this paper. These documents would also discuss general notions and techniques appropriate for differentiating instruction, learning, and assessment for all learners in all subject matter areas.

In an era of the US No Child Left Behind Policy and high stakes standardized testing, discussions regarding assessment practices could be founded upon student learning rather than countless facts associated with each subject matter. As previously stated, 21st Century learners must continually learn how to continually learn. Based on national/international standards on learning processes, educators working in unison across all disciplines may be able to use these learning standards to evaluate a student's subject matter mastery, ability to learn, and progress as a life-long learner. These latter two dimensions may better speak to the goals of education than the temporary learning of facts which may or may not be employed in the future.

Future Directions

The information in this article, determined through an extensive qualitative process, seems to be a small piece of a potentially vast research area on the influence of using learning processes, rather than content standards, to guide teaching and learning. This information has the potential to change the way that teacher educators develop skills in pre-service teachers, to influence curriculum writers to base curriculum on a broader scope including the teaching of digital skills to yield greater capacity for the use of new technologies, as well as to change the practices of teachers to include more advanced processes in their daily instruction. Additional research, including observation of current learning processes used in daily instruction, has the potential to strengthen the development of a K-12 process standard framework by offering evidence of current practice and suggestions for use of such a framework.

It is hoped that this investigation will be followed up and advanced by many other researchers and studies in the future. It is hoped that these thirteen learning processes can be reinvestigated by others, refined, abbreviated, or extended as needed. Moreover, it is hoped that this study facilitates cross-curricular discussion among educators in every field. Thereby, education can be consolidated under the concern for student learning above all other concerns.

Conclusion

In the end, it is the goal of every educator to develop the higher-level thinking and processing of their students. Currently utilized in the national science and math standards, process-based standards may enable the writing of curriculum that is correlated to higher order thinking as defined by Bloom's Taxonomy (Bloom, 1956). Recognizing and utilizing the thirteen learning processes defined herein may assist in developing instructional practices which lead to higher order thinking.

Today, educational studies and discussions most often consider different subject matter areas as disjoint. Education is fractured by segregation according to subject matter. By utilizing the superset of process learning processes, educational discussions, investigations, planning, and development can be unified. The thirteen learning processes discovered through this study give educators and curriculum developers a new platform from which to write integrated, multi-dimensional 21st Century curriculum. Furthermore, a definition and discussion of national/international process standards, or learning processes, could help develop the groundwork for truly integrated (the simultaneous consideration and learning of multiple subject matters, *e.g.* mathematics, science, and music) curricula, instruction, learning experiences, and research. Heading in this direction has the potential to have lasting and meaningful influences on the education of a generation of students who face the unknowns of the 21st Century and beyond.

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