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A TAXONOMY OF STUDENT ENGAGEMENT WITH EDUCATIONAL SOFTWARE: AN EXPLORATION OF LITERATE THINKING WITH ELECTRONIC TEXT*

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ABSTRACT

Readers of the information age increasingly resort to "texts" that are stored, organized, and accessed electronically and rely on symbol systems other than alphanumeric. In schools, multimedia software and hypertexts are increasingly common documents from which students learn. This study sought to document instances of "high" literacy, literate thinking, among elementary school students as they worked with common computer software in the course of their normal school day. Seven distinct forms of engagement emerged to categorize students' work, and these were arranged in order of complexity: disengagement, unsystematic engagement, frustrated engagement, structure-dependent engagement, self-regulated interest, critical engagement, and literate thinking. The taxonomy of student engagement is described with examples. It clarifies other researchers' conceptualizations of high literacy and engagement and integrates them with notions of intrinsic motivation, volition, and self-regulated learning. It also implies new ways for teachers to assess and scaffold student-software interactions to optimize student learning with electronic texts.

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Ordinary educational software, such as, tutorials, simulations, interactive activities, databases, Internet sites, and interactive story narratives, are not often thought of as texts, but such electronic media are increasingly a preferred means of information and entertainment. The International Reading Association and the National Council on the Teaching of English acknowledged this shift in the literate activities of Americans in their recent English Language Arts Standards [1]. The standards state that students should be able to read a wide range of print and nonprint texts and adjust their visual as well as spoken and written language for personal expression in different contexts. The paper page with orderly rows of alphanumeric symbols, and occasional images, is no longer the only nor, in many cases, even the dominant resource for contemporary readers.

Educators must enhance the integration of information technologies in classroom practice. Between 1985 and 1997, the student-computer ratio in precollege education dropped from 63 to seven [2]. In 1997, 77 percent of middle and high school students preferred the Internet rather than books or magazines for research [3]. Yet, in 1998, only 20 percent of teachers felt "very well prepared" to integrate technology in their teaching [4].

Conceiving of software as electronic texts would permit teachers and researchers to borrow constructs from investigations of literacy for application to instructional technology. In general terms, texts are any relatively permanent structures for the storage, organization, and accessibility of a coherent body of information. Electronic texts are information structures stored by and accessible through nonprint, electronic media. Teachers and researchers could examine and support how readers use rhetorical and experiential knowledge and evaluative reasoning to construct personal meanings in transactions with electronic texts, such as educational software.

LITERATE THINKING

Educators should promote "high literacy" with electronic texts. High literacy requires more than decoding skills. Texts are not merely repositories of information; their forms reflect their creators' understandings. Readers build personal knowledge by exploring alternative meanings in textual representations. Such meaning-making requires interpretive skills sensitive to text structure, context, and perspective.

We define high literacy as "literate thinking," a process of personal meaning-making possessing three essential elements:

1. A sensitivity to the structure of text and an ability to evaluate and interpret the significance of its forms;
2. A sophisticated view of and skill with the possibilities of interpretation, that interpretation of a document may evolve over time, that more than one interpretation is possible, that perspective can influence understanding of

text, and that interpretation from multiple perspectives enhances understanding of text;

3. An awareness of personal intellectual, perceptual, and emotional associations evoked by transactions with text and an ability to interweave these associations with interpretations, evoking insights into one's prior personal experiences.

Our definition of literate thinking integrates articulations of high literacy made by several other researchers. Bereiter and Scardamalia, for example, see high literacy as an act of intentional learning involving problem-solving and self-regulatory skills deployed by complex executive structures [5]. For Spiro and Jehng, high literacy is characterized by cognitive flexibility, spontaneous, adaptive restructuring of schemas to solve problems of comprehension and application in the reading of texts [6]. Rosenblatt advocates the importance of aesthetic reading [7]. Aesthetic reading emphasizes the sensations, images, feelings, and emotional and intellectual associations evoked during reading. Efferent reading, by contrast, concerns "what is to be retained for later use, such as information, directions for action, summation, or publicly verifiable 'facts'" [8]. These themes are reflected in our notion of literate thinking.

Our notion of literate thinking was also influenced by Langer's definition of four stances in "literary thinking" [9, 10]. In one stance, a reader seeks a general sense of what a text is about, relying on prior knowledge and experience and document features to generate general impressions (a holistic stance). In another stance, a reader explores understandings of a text, asking questions to extend those understandings into "horizons of possibility" (an exploratory stance). Third, a reader uses emerging understandings to reflect on his or her personal life (a reflective stance). A fourth stance is that of the critic, one who evaluates emerging understandings, characteristics of the text, and one's experience of the text (a critical stance). A reader can move among stances in any order. These stances (holistic, exploratory, reflective, and critical) emphasize sensitivity to text's structure and one's personal response to that structure.

STUDENT ENGAGEMENT WITH TEXT

We presume that high literacy entails high engagement in interpretive acts. We define engagement as the mobilization of cognitive, affective, and motivational strategies for interpretive transactions with text. This definition of engagement has important distinctions from others. For example, some equate engagement with time-on-task [11, 12], but such a definition implies that more able, faster readers are less engaged than less able readers. For most scholars, "engagement" entails some kind of mindfulness, cognitive effort and deep processing of new information [13].

Another view equates engagement with intrinsic motivation [14-16]. For Jacques, Preece, and Carey, "learners are 'engaged' with educational multimedia when it holds their attention and they are attracted to it for intrinsic rewards" [17]. Though intrinsic motivation may foster engagement [18, 19], it does not differentiate attraction to superficial aspects of text and "mindful" involvement. Simple conceptions of intrinsic motivation fail to address issues of volition, complex cognitive-affective-motivational acts that manage and implement goals in the face of distractions [20].

Some researchers equate engagement with self-regulated learning [21]. However, self-regulated learning, the planning, monitoring, and managing of one's own learning, is often a "cold" construct, emphasizing metacognitive processes over meta-motivational and meta-affective aspects of personal meaning-making [22, 23]. Guthrie strongly distinguishes engagement from self-regulation: "I shift from viewing [engagement in] literacy as the self-regulation of a cognitive system to seeing [engagement in] literacy as the self-determination of a person with purposes" [24]. Guthrie and his colleagues conceive of engagement in terms very similar to the notions of high literacy described above [25].

DIFFERENT KINDS OF ENGAGEMENT

High literacy requires high engagement, the coordination of cognitive, affective, and motivational strategies. However, is engagement always "high"? For Nystrand and Gamoran [26], substantive engagement requires "sustained commitment to and engagement in . . . the problems and issues of academic study." However, procedurally engaged students comply with minimal requirements for accomplishing school assignments, and disengaged students are off-task. Corno and Mandinach equated self-regulated learning with full-blown engagement, but described three other possible forms of engagement [21]. Recipient learning reflected generally low strategy use. Resource management reflected high use of cognitive strategies to obtain but not transform information. Task-focused learning reflected high use of cognitive strategies to change but not acquire information.

More detailed differentiations are possible. Lee and Anderson distinguished seven levels of engagement based on three standards [27]. The most minimal standard, behavioral engagement, merely showed that a student was attentive and involved in classroom activities. The three lowest forms of engagement (levels 7 to 5) reflect no behavioral engagement, only disruptive or inattentive behaviors. Level 4 reflects successful behavioral engagement. Level 3 describes behavioral engagement with ambiguous evidence of cognitive strategy use, and level 2 shows dear evidence of behavioral and cognitive engagement. Only in level 1 is the student "fully" engaged, behaviorally, mentally, and independently of teacher solicitation.

Ainley identified six "styles of engagement" among 137 11th grade females in a cluster analysis of their general ability, learning goals, and beliefs [28]. Detached and disengaged groups showed low involvement in learning (though detached students showed higher ability and preference for "deep" learning strategies). Committed and engaged groups reflected high involvement in learning (though the committed group showed higher ability and preference for "deep" learning strategies). The hopeful and keen-to-do-well clusters reflected students who would work compliantly in the classes, though the "keen" group had somewhat higher ability.

STUDENT ENGAGEMENT WITH EDUCATIONAL SOFTWARE

Facilitating student engagement in literate thinking should be a primary goal of research and practice with instructional technology. Identifying student, software, and contextual interactions that promote high literacy would help us understand and enrich the interdependence of motivation and cognition in learning. But discussion of student engagement with computer software has only begun. For example, Jacques, Preece, and Carey generally suggested that software content, software features, and learning task might influence student engagement with software [27]. Schwier suggested that student engagement with software will be reactive, proactive, or mutual, depending on whether the software is tutorial, generative, or mutually adaptive (as in artificial intelligence software) [29]. Mandinach and Corno found ability and gender to be related to student engagement with problem-solving software [30].

We know something about how specially constructed software, such as, Computer-Supported Intentional Learning Environment (CSILE) software [31, 32] and criss-crossed hypertext [33], might foster engagement in high literacy. But do students engage in literate thinking with conventional software in ordinary classrooms? Research must clarify engagement itself, especially with educational software as electronic text, before identifying mediating influences in learning environments and instruction.

THE STUDY

We sought to describe literate thinking in natural interactions with conventional educational software without resort to potentially distorting effects of self-report, think aloud, special task definitions, videotaping, or other methodological or curricular interventions. We also searched for other behaviors related to literate thinking.

Research Context

We observed pre-K through sixth grade students in an urban elementary magnet school for science and technology. The students varied in culture, ethnicity, ability, and socioeconomic status, but were generally facile with computers. The school's technology objectives emphasize operational competence through regular and varied experience, with no explicit program to foster higher thinking or literacy skills with software.

We observed students during their weekly half-hour visits to the school's computer classroom. Typically, the technology coordinator introduced operational features of the session's assigned software. Students then worked alone, though spontaneous, nondisruptive peer interactions were permitted. The regular teacher and technology coordinator, and sometimes older peers, assisted students individually. Students received no grades for their computer work, nor were specific learning objectives defined.

Computer classroom sessions permitted observations of various grades, software, types of students., and types of class cultures in a non-evaluative context. Due to the school's "magnet" status, observers in the computer classroom were not unusual and had no apparent impact on classroom operation or individual students' work.

Data Collection

Typically only one observer was present during any given session. Observers sat close enough to see a student's activity and the computer's monitor, but far enough to go unnoticed by the student. Because seats were often not assigned, convenience and unobtrusiveness of observer's location determined student selection. Efforts were made to vary gender, grade, and ethnicity in observations.

Immediate field notes recorded student-software transactions, including students' software manipulations, body posture, off-task behavior, and verbalizations. Notes included salient contextual factors and the observers' momentary reflections. After sessions, observers elaborated notes into fuller, more readable descriptions. Reflective comments, particularly regarding indications of student motivation and strategy use, were added in brackets. Observers jointly reviewed each other's notes to resolve ambiguities. Where inferences about student behaviors were made, plausible alternatives were constructed, and confirming or disconfirming evidence was sought in other portions of the session's description. The researchers jointly articulated general trends and themes and significant phenomena for each session.

Analysis and an Emerging Taxonomy of Modes of Engagement

After 25 observations, we reviewed session descriptions for emerging themes. Some students navigated software competently, but without apparent regard for specific learning goals (as in self-regulated learning). Instead, their decisions seemed designed to stimulate and maintain personal interest. We labeled such strategic decisions as "self-regulated interest." Other students' transactions closely paralleled software structures. For example, some students used menus as checklists for systematic examination of software; others dutifully clicked on all available operational options regardless of whether such access furthered learning goals or interest. We called this interaction style "structure-dependent engagement."

Though no behavior was classified as literate thinking, we wondered if kinds of observed engagement could be arranged according to the degree that they approximated literate thinking. A seven-level taxonomy was developed by the first author and refined in discussion with the second author. We began to define behavioral indicators that could be taken as evidence of particular forms of engagement.

A Second Analysis and Results

The authors independently classified the 25 observations by engagement type, even though notes were not gathered for this specific purpose. Our judgments agreed perfectly on 19 of 25 sessions (76 percent agreement). Only three disagreements were as much as two levels apart; all disagreements were resolved by discussion.

Over the next five months, we conducted 53 more observations, completing 78 observations of 43 individual students. To challenge the robustness of the taxonomy, our observations varied across numerous factors that might influence engagement: grade level, gender, age, ability, ethnicity, type of software, etc. (See Table 1 for grades and types of software represented in observations.) Reviewing field notes, we looked for student behaviors that defied classification, but the taxonomy proved a very robust means for describing student transactions with software irrespective of student characteristics or software types.

Taxonomy of Student Engagement with Educational Software

A taxonomy of student engagement with educational software differentiates how students respond to software structure (see Table 2). In electronic text, "structure" includes navigational and operational interfaces, representations of content, and implicit or explicit demand characteristics embodied in the software. Structure defines a universe of possible interactions. Students' knowledge, motives, and goals combine with structure and contextual demands to determine students' experience of these possibilities. Thus, differing student, software, and contextual characteristics will determine varied kinds of engagement with software.

We observed middle levels of engagement most frequently. Structure-dependent activity occurred in about 50 percent of our observations. Upper and lower extremes of the taxonomy were rarer; no instances were classified unequivocally as literate thinking and only five as disengagement. We presume that

Table 1. Percentages of 78 Observations Representing Different Grade Levels of Elementary School Students Interacting with Different Types of Educational Software

Grades	
Pre-kindergarten	11%
First-Third	49%
Fourth-Sixth	40%
Types of software	
Simulations	27%
Activity collections	22%
Tools	20%
Tutorials and Internet	7%
Games	9%
Living books	9%
Gender of Observed Students	
Total students observed	43
Number of males observed	25
Number of females observed	18

different distributions would be found in different contexts with different student-software matches.

Level 1: Disengagement—Disengaged students stop working with the software or maintain disinterested random activity as a cover for mental and emotional withdrawal. Disengagement was rare in our context. Sometimes students would become disengaged with particular software, but re-engage with alternative unassigned software. In other instances, the student would avoid the computer itself.

First-grader Damien[1] worked with tutorial software. From a central menu, this software allowed access to independent subsections, each containing text and simple activities illustrating concepts in astronomy and space travel. Damien chose an activity where students could drag planets to correct positions in orbits around the sun. Damien stopped after a few seconds and returned to the menu. He chose another activity about naming celestial objects. He turned the virtual pages too quickly to interact with them, then laid his head down. Damien returned to the menu and selected an activity on space travel. He put cartoon characters in a spaceship and watched them take off. After scanning the classroom, he passed a

[1]Student names are changed to protect confidentiality, though gender is accurately reflected. No significance should be attached to the relation of gender and taxonomy level as no such relation appeared in the observations.

Table 2. Characteristics of Seven Levels of a Taxonomy of Student Engagement with Educational Software

Taxonomy Level	Level Description
Literate thinking	*Student interprets software content from multiple and personally meaningful perspectives.* Student manipulates software features to explore alternative interpretations as an opportunity to reflect on personal values or experiences.
Critical engagement	*Student investigates operational and content-related limitations of the software.* Student manipulates software features to test personal understandings or limitations of the software presentations.
Self-regulated interest	*Student creates personal goals within the software to make the software as personally interesting as possible*. Student adjusts software features to sustain deeply involved, interesting, or challenging interactions. Student adapts software for personally defined purposes.
Structure dependent engagement	*Student is sensitive to and competent with software operation and navigation.* Student pursues goals communicated by the software and responds to operational, navigational, or content organization.
Frustrated engagement	*Student possesses clear goals when working with the software but is unsuccessful in accomplishing them*. Student knows what the software can do, but cannot accomplish it. Student *may* manifest stress or frustration in negative comments, confusion, aggression, erratic behavior, agitation, distress, or anxiety.
Unsystematic engagement	*Student has unclear goals when working with the software.* Student moves from one incomplete activity to another without apparent reason. Student successfully completes simple tasks within the software but does not link tasks for higher-order goals.
Disengagement	*Student avoids working with the software or discontinues use prematurely*. Student may tinker with software in a seemingly purposeless and unresponsive way. Or, student may in fact turn away from the software or resist using it at all.

few more space voyage screens quickly, then repeated the rocket launch. He laid his head on the desk again. He manipulated his characters in a space walk, then put his head down again. He passed a few screens and put his head down again. Fidgeting, looking around the classroom, laying his head down, scanning software screens with little or no interaction characterized Damien's involvement with the software. Damien never was involved with the software structure more than superficially.

Level 2: Unsystematic engagement—In unsystematic engagement, students seem confused or "lost," so inconsistent are their choices within the software structure. Students may demonstrate limited competence with portions of a program, but fail to link these local competencies into a long-term, planful strategy. They may express or temporarily pursue long-term goals, but not settle on a means of achieving them.

First-grade student Alysa's software introduced the alphabet. The main menu consisted of blocks showing the letters of the alphabet. Selecting a letter displayed a word beginning with that letter and a memorable animation or activity. Alysa clicked on the letter "R" but never accessed the related activity. She chose "A" and accessed an airplane animation. Alysa began moving in and out of the software by clicking on and off the application's window. She clicked on "S" and accessed an animated snail. She discovered that typing on the keyboard activated letters on the menu, activating "C" and "O" this way. Then Alysa clicked or typed on a string of letters—M, V, X, W, N—without accessing related activities. Alysa almost accidentally quit the software. The teacher arrived and guided Alysa to focus on one activity. Together they explored the activity associated with N (counting numbers), and Alysa showed considerable initiative in demonstrating numerical competence.

Alysa worked well enough with the educational software to remain engaged during the entire session. She was interested in what she was doing and understood basic navigational and operational software features. However, she never assembled her understandings of the software and its content into a coherent agenda. It was not until a capable adult gently constrained her choices and discursively directed her attention that Alysa's abilities with the content could be fully deployed.

Level 3: Frustrated engagement—In frustrated engagement, students possess particular goals and understand that the software can enable these goals, but they lack sufficient navigational or operational competence to use the software effectively. Frustrated engagement is "higher" than unsystematic engagement because students sustain purpose for their transactions with electronic text. Some students can persevere in frustrated engagement, but many disengage.

Katherine, a fourth-grade student, interacted with a simulation of aquatic life in a coral reef ecosystem. Students could guide a self-selected fish around a reef by moving the mouse; a mouse-click on an appropriate reef image allowed the fish to eat. Katherine chose a fish, guiding it around the reef but failing to let the animal eat. The fish died. Katherine chose a second fish and moved around the reef again, but failed again to eat. The fish died. She stared at the screen for some time, and resumed with a third fish, again without clicking the mouse. Katherine began glancing around the room indifferently. “I don’t want to do this computer,” she announced loudly and quit the application. On quitting, the computer bombed; the teacher restarted it. Katherine said, “I am not playing this game. I can go to no game.” She announced, “This is a boring computer.” Katherine finished the session simply looking around the room.

Apparently, Katherine had some idea about what this software would do and an initial interest in her interactions. She lacked crucial operational knowledge about the software, knowing how or what to feed her virtual fish. Without that knowledge, combined with unfortunate computer failures, she could not achieve her goals , and Katherine ultimately disengaged.

Level 4: Structure-dependent engagement—Structure-dependence occurred in about half of our 78 observations. In structure-dependent engagement, students’ work is competent and compliant with the software’s demand characteristics. If software is unfamiliar, structure-dependence may focus on a careful and orderly exploration of the range of software options. With familiar software, students in this mode perform tasks in a competent, routine manner. We call such engagement “structure-dependent” because student activities are cued by the software interface.

Yvonne, a first grade student, demonstrated structure-dependence with tutorial software. The software menu offered eight sections on different plant topics. Each section presented sequences of activities, allowing students to arrange objects and labels on the screen. Correct placement of objects evoked feedback, but correct label placement did not. Yvonne examined each section of the software in the order presented in the menu. Within each section, she sequentially viewed the activities. Only with confusing or boring activities did she review work she already accomplished or prematurely return to the menu. In each activity, Yvonne carefully and dutifully manipulated each object given for her consideration. Yvonne repeatedly dallied over placement of labels with objects, apparently unsure of her decisions in the absence of feedback. Yvonne showed considerable navigational, operational, and content competence with the software, but did not stray from the structure implicit in the software’s representations.

Level 5: Self-regulated interest—Self-regulated interest strategically employs content, operational, and navigational knowledge to maintain a heightened state of personal interest and excitement. Self-regulated interest can appear erratic as new goals or personal challenges emerge from interactions with the software, but choices optimize interest in the software experience. Self-regulated interest epitomizes strategies for maintaining intrinsic motivation (e.g., Csikszentmihalyi) [34]. Self-regulated interest was manifest during at least part of 22 percent of our observations.

Third-grader Melissa worked with software that provided several discrete tasks: sorting, building objects from blueprints, arranging images in narrative sequences, examining adaptations of organisms to seasonal changes in a pond, and demonstrating different weather conditions. Melissa began by successfully building and painting objects from blueprints. Moving to the sorting activity, she repeatedly accomplished tasks easily. She increased the difficulty of the sorting tasks by adding additional categories. Her behavior and posture began to indicate waning interest; Melissa stopped sorting to look at the weather activity. She did not stay, however, but went to the sequencing task. Completing several sequences, Melissa returned to blueprints to repaint some objects she saw before. When Melissa noticed a peer investigating the software's pond, she asked how to access it. Given verbal directions, Melissa accessed the pond and finished the session giggling at animations of different organisms. Notice Melissa's considerable navigational, operational, and content competence throughout the session. Melissa used her knowledge of the software structure to strategically pursue activities of greatest interest in the moment.

Level 6: Critical engagement—Critically engaged students create "problems" or personal tasks to test the limitations and possibilities of the software and their understanding of its content. Students also might identify special strengths of content representations relative to other representations they have experienced or imagined. In evaluating navigational and operational features and content representations for errors, biases, ambiguities, and strengths, students combine strategies associated with self-regulated learning (e.g., Winne) [23], intentional learning (e.g., Bereiter and Scardamalia) [5], and critical thinking (e.g., Ennis) [35].

Greg critically engaged with software that allowed manipulation of abstract objects and cartoon-like animations. Designed to stimulate creativity and support pattern recognition skills, these software activities were either structured or unstructured. Structured activities allowed students to create or match patterns of sound. Unstructured activities gave students access to objects of different sizes, shapes, colors, motions, and sounds. Students could observe prepackaged arrangements, rearrange prepackaged displays, or create new displays. In structured activities, Greg consistently chose the challenge of matching patterns. In the unstructured activities, Greg deconstructed prepackaged patterns, carefully removing and replacing each element to see how they fit in the whole. In the unstructured setting, Greg attempted to duplicate a prepackaged object-motion-sound pattern, systematically adjusting elements to increasingly approximate the prepared patterns. At other times, Greg created arrangements and systematically altered single features to study their effects. Greg's interactions were quite sophisticated tests of the computer's capacities and his abilities to manage them.

Level 7: Literate thinking—No unequivocal instance of literate thinking was observed. Our definition of this category elaborates other scholars' articulations of high literacy and engagement. In literate thinking, a student reflects on the meaning of the software's navigational, operational, or content structure. This reflection personally involves the student, accessing prior knowledge and experience, personal beliefs, values, and feelings. In literate thinking, a student can entertain alternative interpretations of text and use these understandings to reflect on personal experience.

The observation most resembling literate thinking occurred under special circumstances, in an interview with a fifth grade student. In prior observations, we had noticed Shannon's precocious manner with peers and teachers and her extraordinary facility with navigating and operating software. In conversations, she told us that she preferred "fiction," stories about children and their problems, to software. We encouraged her to select software that made her feel the way good fiction does. She chose *Arthur's Teacher Troubles,* a "living book" that combines text and animation to tell the story of Arthur who was assigned to Mr. Ratburn, the strictest teacher in his school [36]. To the students in the story, this teacher seemed almost cruel, but under the teacher's tutelage, Arthur succeeded in winning first place in the spelling bee.

Shannon's progress through this software was unremarkable, flipping virtual pages and exploring animations as her peers did with other "living books." However, Shannon gave greater weight to the words read from the top of the screen by a narrator. Shannon followed the reading with her eyes, and sometimes her mouse, before she attended to the animations, quite the reverse of her peers.

In a post-session interview, Shannon immediately started to talk about how "the same thing had happened to me" last year. She had fallen one word short of winning a popular spelling bee and identified with the character who lost to Arthur. About the early defeat of the smartest character in the story, Shannon said, "She got exactly what was coming to her. She was so proud and cocky. . . ." When asked about how Arthur must have felt after winning, Shannon rolled her eyes with glee and said, "The applause was great." She also delighted that Arthur's often-taunting sister was going to have Mr. Ratburn as her teacher in the following year. In short, Shannon was very personally involved in the narrative, finding a natural bridge between the fiction and her personal life and understanding the story's events from the perspective of various characters.

DISCUSSION

We began this exploratory study to identify observable characteristics of high literacy in student transactions with educational software. We defined high literacy as literate thinking: awareness of and ability to interpret the structures of the text, awareness of the ways that interpretations can shift and depend on perspective, and an illumination of personal experience as a result of interpretive processes. We selected an urban elementary magnet school for its diverse population, its extensive use of educational software, and its emphasis on operational competence with software. Two researchers conducted 78 naturalistic observations of 43 elementary school children (pre-K through sixth grade) working with educational software in a computer classroom.

Where was Literate Thinking?

Literate thinking was not definitively observed among these students. Literate thinking might proceed internally with no external evidence. Indeed, the best evidence of literate thinking came in an interview. We selected a student for her precociousness in initial observations, and she chose software she thought had a personally involving narrative. The interviewed student's interactions with a "living book" appeared little different from her peers'. In interview, however, the student showed awareness of the genre of the text and its general structure (a holistic stance) [10], how it might be interpreted from different perspectives, and how it was relevant to her personal life (a reflective stance) [10]. She manifested aesthetic reading [8], reflecting on emotional and intellectual associations evoked by the software, and cognitive flexibility [6], answering questions about the narrative from a variety of perspectives.

Perhaps literate thinking rarely takes place "on-line." "On-line" interactions may provide raw experiences for later reflection and discourse. Literate thinking itself might take place in these delayed reflections and discussions. Perhaps literate thinking is more common among older students or with narrative software.

A Taxonomy of Student Engagement

Though literate thinking was not conclusively observed in this setting, students related with software in identifiably different ways. A unitary notion of engagement could not describe the complex interconnections between students' cognition and motivation. In spite of the students' general enthusiasm, the taxonomy distinguishes various levels of interpretive sophistication. Arranging modes of engagement by their approximation to literate thinking, a coherent seven-level taxonomy emerged. Higher taxonomic levels reflected more strategic responsiveness to software structure and greater ownership of personal knowledge and its construction (Table 3).

The taxonomy's three "simplest" levels differentiate the relative competence and willingness of students to navigate and operate electronic text. In disengagement, navigational and operational competence or interest is so lacking, the student declines purposeful interaction. In unsystematic engagement, students have sufficient navigational and operational skill and interest to continue interacting with the software, but do not arrange their skills to pursue long-term goals. Frustrated engagement is characterized by an inability to pursue long-term goal due to deficits in operational knowledge or skill. Unsystematic and frustrated engagement may continue indefinitely, transition into "higher" engagement as

Table 3. Comparison of Taxonomy Levels by Strategy Use, Goals, and Quality of Learning

Taxonomy level	Strategic use of navigational and operational features	Student goals	Quality of learning
Literate thinking	Coordination of operational and navigational strategies	Personal meaning-making through multiple interpretations of text; situated understanding	Integrating new knowledge with personal values and beliefs
Critical engagement	Coordination of operational and navigational strategies	Evaluating and extending knowledge	Self-initiated and systematic knowledge-building
Self-regulated interest	Context-dependent use of complex navigational and operational strategies	Maintaining high involvement	Developing software and content expertise in areas of interest
Structure dependent engagement	Mastery of basic operational and navigational strategies	Achieving task or software goals	Developing schema for content comprehension
Frustrated engagement	Difficulty with operation or navigation of software	Achieving task or software goals	Developing schema for software use
Unsystematic engagement	Limited awareness of software structure	Interacting with perceptible aspects of software	Acquiring disconnected "facts" about software and content
Disengagement	None	No software goals	None

necessary skills evolve, or turn to disengagement as the student becomes dissatisfied with the experience.

The taxonomy's "higher" levels presuppose navigational and operational competence. The student can attend to "long-term" goals and interactions with the text's content in various ways. These modes of cognitive engagement show significant correspondences with Langer's four stances of literary thinking [10]. (Note, however, that in her work, Langer did not arrange the stances hierarchically.)

The Taxonomy and Langer's Four Stances

In structure-dependent engagement, students meet goals communicated by the software or the task situation. The software interface rules student decisions. Structure-dependent engagement requires a "holistic" stance where the student will "gather enough ideas to gain a sense of what the work [the software] will be about" [10]. (Frustrated students also may manifest a holistic stance, though they lack important operational competencies.) This sense of what the software is about can evolve over time, but it may create an essential frame for other kinds of engagement.

In self-regulated interest, students work strategically, not so much to meet software or task requirements, but to maintain high interest. Sometimes as erratic as unsystematic engagement, self-regulated interest displays operational and navigational competence and a consistent purpose. As in Langer's "exploratory stance," the student is immersed in the text, drawing from personal experience and knowledge to extend understandings of the text into "horizons of possibility."

Critical engagement most resembles Langer's critical stance. The student is "stepping out and objectifying the experience," reflecting on, analyzing, and evaluating "our understandings, our reading experience, and the work itself" [10]. The student may test limits of the software's representations by testing problems that will shed light on the software structure and its capabilities.

"Highest" engagement, literate thinking, most resembles Langer's reflective stance. Transactions with the text become opportunities for reflecting on one's own life experiences. The reader can see many meanings in the same text that evolve and illuminate personal values.

Literate thinking likely involves all four of the higher forms of engagement. In transactions with software, students' attentions may shift from goals, to structure, to personal meaning-making, to excited interest, to critical evaluation, in varying orders. However, the taxonomy implies interdependence among Langer's four stances. Students may require structural sensitivity, awareness of their own interests, and critical capacity in order to think literately. The taxonomy also adds disengagement and unsystematic and frustrated engagement to Langer's four stances.

The Taxonomy and Other Engagement Classifications

Our taxonomy emerged from naturalistic observations of students interacting with ordinary educational software. Lee and Anderson logically derived a seven-level system of engagement [27]. Ainley defined six independent (unarranged) engagement styles from responses to a learning process questionnaire [28]. Despite their different sources, there are noteworthy similarities across the three schemes (see Table 4).

Table 4. Comparisons among 5 Frameworks for Understanding Kinds of Student Engagement

Bangert-Drowns & Pyke Taxonomy of engagement *Source:* Classroom observation	Langer (1995b)* Four interpretive stances *Source:* Classroom observations	Lee & Anderson (1993) Engagement levels *Source:* Coding framework	Ainley (1993)* Engagement styles *Source:* Questionnaire responses	Corno (1993) Volition in learning *Source:* Theory integration
Literate thinking	Reflective			
Critical engagement	Critical	Level 1: Self-initiated behavioral and cognitive engagement	Committed	Self-regulation
Self-regulated interest	Exploratory			Volitional processes
Structure-dependent engagement	Holistic	Level 2: Behavioral and cognitive engagement	Engaged	Metacognitive processes
Frustrated engagement		Level 3: Behavioral and ambiguous cognitive engagement	Hopeful, keen-to-do-well	
Unsystematic engagement		Level 4: Behavioral engagement		Motivational and cognitive factors
Disengagement		Level 5-7: Disengaged	Detached, disengaged	

*Langer (1995b) and Ainley (1993) did not specify hierarchical arrangements in their models.

Ainley's most successful styles of engagement are engaged and committed, the committed style reflecting highest abilities and most frequent resort to "deep" cognitive strategies. Lee and Anderson's highest level depicts self-initiated cognitive and behavioral engagement. These resemble, though in less detail, our self-regulated interest, critical engagement, and literate thinking. Lee and Anderson's three lowest levels (levels 5-7) distinguish subtly among disengagements, depending on student disruptiveness or slightest use of cognitive strategies. Ainley distinguished two kinds of disengagement, detached students (sufficiently able but unwilling to engage in learning) and disengaged students of average ability. Our lower levels of engagement (unsystematic, frustrated, and structure dependent engagement) resemble Lee and Anderson's levels 2-4 and Ainley's hopeful and keen-to-do-well clusters (generally compliant and strategically naive learners).

Engagement and Volition

Higher levels of engagement on our taxonomy reflect increasing volitional competence [20]. In Corno's analysis of volition in learning, students derive goals from personal motivations and understandings of themselves and learning contexts. Volition helps students achieve their goals through metacognitive, meta-motivational, and meta-affective strategies. Self-regulation coordinates volitional strategies for planning, monitoring, and adapting mental and physical activities. Self-regulation and volition thus depend on certain cognitive, affective, and motivational prerequisites [37].

Our taxonomy presents a similar hierarchy. Unsystematic engagement reflects nonstrategic motivation and mental attention. Higher taxonomic levels (frustrated and structure-dependent engagement) reflect increasing capacity to employ metacognitive strategies to monitor progress toward goals. Volitional capacities, strategic prioritization of goals and perseverance in pursuit of personal interests, appear clearly in self-regulated interest. Our critical engagement resembles Corno's self-regulated learning, encompassing volitional strategies and adding planning and evaluative activities [20]. However, by making literate thinking the capstone of our taxonomy of engagement, we link personal meaning-making, championed by Guthrie and echoed in definitions of high literacy, to what otherwise might be solely academic learning.

Implications for Instructional Research and Practice

Obviously, the taxonomy of student engagement integrates and extends various theoretical notions of literacy, engagement, motivation, and volition. In addition, the taxonomy of modes of student engagement may facilitate articulation of factors which foster high literacy. Possessing a multimodal and progressively arranged description of engagement is a necessary precursor to investigations of student, software, and contextual characteristics related to enhanced engagement. Educators and researchers could use the taxonomy to characterize moment-to-moment shifts in a student's engagement and to isolate qualities of context, student, and software that might contribute to those shifts. For teachers, the taxonomy can provide a framework for new ways of planning their own educational goals for computer use and for assessing the sophistication of their students' interactions with software.

The taxonomy also raises a number of questions for further investigation. The most obvious questions regard relations among the taxonomy levels. The order of levels implies prerequisites for literate thinking, and capacities for structural awareness (as in structure dependence), self-regulated interest, and critical engagement make plausible candidates. "Lower" levels (frustrated engagement, unsystematic engagement, and disengagement) may define engagement forms that endanger the development of literate thinking. These plausible relations need confirmation.

We cannot yet determine the degree to which engagement is situationally dependent. A student might be structurally dependent one day and disengaged with the same software on a subsequent occasion. Alternatively, at least some students may be predisposed to interact with electronic text in a given mode; that is, one student may be generally critical, and another disengaged. Our study was not designed to examine this issue; it will have to await further inquiry. If such predispositions exist, how do they develop, and can they be overcome to foster "higher" engagement?

The taxonomy does not define determinants of engagement levels. Three students may be frustrated with an assigned electronic text, one because he can not navigate the software, one because he does not understand the content, and a third because the software's goals are inconsistent with her interests. Ainley included ability as a factor in analyzing kinds of engagement and distinguished two kinds of disengaged students: those who can but won't and those who can't and don't [28]. The taxonomy evolved as a means to describe, not explain, different modes of engagement; subsequent research will shed light on causes for these modes.

The taxonomy of student engagement may be useful for teaching students to identify and initiate appropriate modes of engagement in particular learning and software contexts. In some learning situations, critical engagement is called for; in others, structure dependence is adequate. It could help teachers map paths from lower to higher forms of engagement. We are hopeful that with proper tasks, scaffolding of activity, and accountability for engagement, the great majority of students can make more literate use of educational software.

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