

The Link-Systems Methodology:

The Practice of Integrated Cognitive-Contextualized Learning

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About the Author

Link-Systems International, Inc. (LSI) provides online tutoring through the NetTutor® Online Tutoring Service. NetTutor was created in 1996 by mathematics professors at the University of South Florida in Tampa, where LSI is still based.

David Kephart, former Director of Online Tutoring at LSI, has taught mathematics at the University of South Florida for a decade. Currently the Director of Academic Research at LSI, Dr. Kephart facilitates research studies and academic collaboration with universities, community colleges, K-12 schools and other educational programs.

As both an adjunct professor of mathematics and active researcher in learning theory and practice, Dr. Kephart has published articles in peer-reviewed journals about online education as well as in the field of discrete mathematics.

The LSI Methodology: The Case for Integrated Cognitive-Contextualized Learning

Introduction: How Learning Theory and Practice Meet

Link-Systems International, Inc. (LSI) was founded in 1995 with the mission of creating and developing tools to bring instruction and learning to the Web. Inspired by the development of Java, the company's founders systematically built applications and services to support every aspect of the learning experience online.

Aiming for usability and accessibility as its watchwords, the company created the earliest online educational Web-conferencing tool, the WorldWideWhiteboard®. LSI demonstrated the viability of the WorldWideWhiteboard by using it to implement the first commercially available synchronous (real-time) online tutoring service, called NetTutor®. LSI targeted verifiable compliance of its tools with established instructional standards as part of its mission. This paper discusses three issues, namely (1) the theoretical basis for LSI's claim that its tools promote learners' success, (2) the manner in which learning theory is applied to the development of LSI technology and (3) the wealth of empirical data and independent research that verifies the efficacy of the LSI methodology, tools, and their applications. In the latter, we include the record of products sharing the same theoretical basis but developed by others.

A Word about Modern Learning Theory

The great majority of educators today acknowledge the importance of constructivist thought in education. According to this outlook, learning takes place through the learners' construction of knowledge in a social context. The skill of the

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educator in the subject, however necessary to teaching, is not the heart of it; it is the educator's facilitation of learner access to the subject matter that counts. Learning, as a process of constructing knowledge, is equally a process of taking on an active social role and working with the objects of knowledge.

Aside from its epistemological implications, this theory clearly calls into question the adequacy of the vision of the teacher as a scholar in the field who drops nuggets of wisdom into the open brains of students. Constructivism posits learning as the activity of the learner. The all-important role of the educator is to *facilitate* and *collaborate with*, rather than simply instruct the learner. The teacher educates to the degree that she catalyzes the learning process. Constructivism focuses not on conveying facts but on the social process through which the learner moves from her current state of knowledge, understanding, and skill to increasing degrees of mastery over the subject matter and its relationship to the world.

Constructivism has proven seminal not just in throwing a new light on the act of learning but in inspiring new techniques and modalities of educator activities. The list of proposed means for training teachers and designing instruction along constructivist lines is immense and growing. The advent of the Internet and the realization of online learning techniques have played a decisive role in elevating these approaches to acceptance by the main body of educators and in accelerating the proliferation of ideas about how to educate. Separate theories deriving from the advent of practical methods of online learning and the constructivist theoretical root, as a result, are too numerous to comprehensively list.

We will consider the two over-arching families of constructivist thought and explain the exemplary methods located in each upon which a rigorous modern theory and practice of education can be based. We explain the additional requirement identified as the premise for adopting both of these rigorously-tested theories in a single approach and for moving them from the laboratory environment to application in the real, burgeoning world of online education.

The first main strand of constructivist thought is **cognitive constructivism**, the idea that learning takes place through the development of discrete cognitive abilities. The individual, that is, constructs learning through the mastery of successive cognitive skills or stages of learning. The role of the educator is therefore to point the way forward in the mastery of these skills.

The second main strand is that of **social constructivism**, the conception that learning is constructed through social interaction. The learner, according to this position, constructs learning out of a given social context. The educator must identify the learning goals within familiar components of the learner's situation and provide a superstructure (e.g., of hints and suggestions) for the learning process.

We will look at how these two strands of constructivist thought about education have contributed to the development of learning theory and how technology, in particular Web-based tools, allows for realizing and testing their conclusions. Following this, we consider a consistent integration of the two strands, overcoming the limits of each. Finally, we look at how such an integration of the two—the best practices established from both cognitive learning and social, contextual learning—drives the development of effective tools for distance education at LSI.

Cognitive Constructivism: Adaptive Learning, Knowledge Space Theory and ACT-R

Cognitive constructivism is prominently associated with the work of Jean Piaget. Famous for describing the stages of a child's development, including psychomotor skills, Piaget painstakingly traced through the interconnections of individual cognitive development and the individual's developing relation to the world (Piaget, 1998). A specific application of this type of approach to education is the formulation by Benjamin Bloom in the 1950s of his well-known taxonomy of the "cognitive realm" of learning. This taxonomy departs from the conception of the classification of learning as a catalogue of the sum-total of human knowledge, i.e., into subjects and grade-levels. Bloom identifies instead "realms" of human activity—cognitive, affective, and psycho-motor—and breaks the cognitive domain into a linked hierarchy of processes, namely, factual knowledge, comprehension, application, analysis, synthesis, and evaluation (Bloom, 1956). In a re-framing of Bloom's taxonomy in 2001, these processes are described as activities and the hierarchy is slightly re-ordered. Learning is understood, that is, as remembering, understanding, applying, judging, evaluating, followed by creating (Anderson, 2001). This more explicitly describes learners' activities or capabilities at each stage, in accord with the principle that the learner is actively constructing knowledge.

Cognitive methods start from, and justify the measurement of learning progress against standards by, the conception that learning occurs in definite stages universal to human development. The idea that universal conclusions can be drawn from an ordering or classification of cognitive achievement is far from self-evident. Mastery of opera, for instance, has historically carried a very different meaning in Italy than in China—why should knowledge itself not be likewise diverse? As it turns out, the concepts humans teach each other are shared globally, reflecting universality in the underlying cognitive processes. For instance, the proof of the Pythagorean Theorem was most likely discovered in China, conveyed to India, and eventually transported to Greece and so, eventually, relies on the same cognitive attainments both in Italy and China.

One well-known realization of cognitive constructivist thought is through the computer-assisted instruction of adaptive learning. Originally linked to behaviorist conceptions of learning, adaptive learning took on a modern form with investigation of knowledge space theory, such as those undertaken by the Belgian mathematicians Jean-Claude Falmagne and Jean-Paul Doignon. This gave a rigorous mathematical support to the construction of a knowledge space through interview with experts in a field and to the tracking of the progress through such a space by human learners, however convoluted that progress. Co-thinkers of Falmagne working at the University of Graz, Albert and Mori write in 2001 of how this works:

The most recent psychological development in the field of e-learning is the Knowledge Space Theory (KST) founded in 1985 by Doignon and Falmagne. KST is a psychological mathematical theory (based on order and lattice theory) using dependencies between the problems and other learning objects in a knowledge domain for structuring the assessment process and the teaching process like a private teacher. Since 1985 the theory has been developed further by Doignon

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and Falmagne (1999), Koppen and Dowling, Albert and Lukus (1999) and others. Basic concepts of knowledge space theory are (a) prerequisite relationships between test items, problems or learning objects (b) the knowledge states of the students and their knowledge space and (c) sequences of knowledge states representing possible learning paths from the individual starting state to the selected goal state. (Albert & Mori, 2001)

In short, adaptive learning starts by formulating a space or collection of elements of knowledge and then performing an initial assessment of the learner's current knowledge state, it poses problems that challenge the learner to move beyond this state, and it tests the learner's standing at the conclusion. Adaptive learning provides both the positive reinforcement as understood from Skinnerian concepts and operant conditioning and self-operated instructional tools for the creative application, evaluation, and of learning. It concludes with an end-assessment of the learner's knowledge state.

Adaptive learning is currently used in training programs, ancillary skill-and-drill material for classrooms, and as supporting material from the publishers of textbooks. An early task of LSI content authors was the development of material for adaptive learning applications. One well-developed form of adaptive learning, on which LSI material is based, is the Adaptive Control of Thought-Rational (ACT-R) theory of cognitive psychologist John R. Anderson at Carnegie Mellon University. In the last decade, ACT-R has been found to match precisely the brain activity of human problem solvers, as shown in fMRI scans. The specific goal of the ACT-R program is to model human cognitive skill-development in the computer to identify the basic tasks necessary for learning. ACT-R based applications use this information to construct intelligent tutoring systems as adaptive learning tools. These systems employ a supporting set of instructional books to promote learner success through cognitive and meta-cognitive activities.

The originators of ACT-R state its principles as follows:

- There are two basic types of knowledge: procedural and declarative. Declarative knowledge includes facts, images, and sounds. Procedural knowledge is an understanding of how to do things. All tasks involve a combination of the two types of knowledge.
- As students learn, they generally start out with declarative knowledge, which becomes proceduralized through practice. Procedural knowledge tends to be more fluent and automatic. Declarative knowledge tends to be more flexible and usable in a wider range of contexts.
- The knowledge required to accomplish complex tasks can be described as the set of declarative and procedural knowledge components relevant to the task.
- Knowledge becomes strengthened with use. Strong knowledge can be remembered and called to attention rapidly and with some certainty. Weak knowledge may be slow, effortful, or impossible to retrieve. Different knowledge components may represent different strategies or methods for accomplishing a task (including incorrect strategies or methods). The relative strength of these components helps determine which strategy is used.
- Learning involves the development and strengthening of correct, efficient, and appropriate knowledge components.
- There are strong limits on students' ability to reason. These limits are referred to as "working memory capacity." As knowledge becomes more proceduralized, it takes up less working memory. (Ritter, S., 2011)

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Elsewhere, ACT-R is described as the “chunking” of knowledge via educational technology (Rosenbloom, Laird, & Newell, *The Chunking of Skill and Knowledge*, 1987). Blending question-and-answer techniques as described above with a sequence of texts, ACT-R based methods have been shown to produce significantly improved performance in learners (Shneyderman, 2001).

The ACT-R research finds that the teacher (whether that is the traditional classroom instructor, an online instructor, or program administrator) may not deploy tools as effectively as the students do. That is, while the human teacher is not part of the HCI upon which the method rests, the student can indeed seek out the required knowledge. Faculty may see intelligent tutoring system as a marginal study form. In one field study, student using an ACT-R based method scored lower, and the authors of the study suggest this is due to the difficulty the faculty had in implementing the program (Pane, McCarrey, Ikemoto, Steele, & Slaughter, 2010).

Cognitive constructivism, correctly setting the aim of improving and measuring the improvement of cognitive skill, has yet to render the formulation of the system objective in teachers’ eyes. Since learning is not strictly an individual activity, educators expect adaptive learning to fit into *their* approaches. The need for learning technology with the broadest possible application is answered, in terms of learner success, by the estimable results of cognitive constructivist approaches. These methods address the cognitive, evaluatory side of learning but do not address learning as social engagement. This is where ICCL turns to social constructivist methods to complete the picture by examining how to link the learning process to the environment in which it takes place.

Social Constructivism and Contextualized Learning

Beginning principally with the work of Soviet psychologist Paul Vygotsky, learning theorists came to recognize that the cognitive activity of the individual learner is framed by social context. Social constructivism hypothesizes that this is because knowledge is not arbitrary cognitive activity but originates in the relationship to an environment *outside* the individual. Social participation makes individual acquisition and internalization of knowledge possible so that, as observed, learning imparted (knowledge constructed) exceeds the cognitive content of teaching. Social context *mediates* and *contributes to* the learner’s construction of knowledge and to her construction of herself *as a learner*. In short, all knowledge is socially learned rather than found innate in a child or even genetically transferred from her parents.

In place of innate forms or reliance on heredity for explanations, Vygotsky hypothesizes the initial equivalence between the language of speech and of thought. Speech convers social interaction; inner speech is the medium of acquisition and internalization (Vygotsky, 1962).

To restate this within the constructivist paradigm, interaction with society enables the learner to construct knowledge that is close to what she has attained so far. Vygotsky called the area of accessible knowledge the learner’s “Zone of Proximal Development.” The effective educator constructs the basis for reaching out and taking hold of this knowledge in a process he calls a *scaffolding* (Berk & Winsler, 1995). Scaffolding catalyzes learning, pointing to the importance of such techniques as guided

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participation. Social constructivism accordingly declares the role of the educator to be essentially facilitative and contrasts this view with the traditional picture of the educator as didactic, that is, as delivering facts. Consequently, social constructivism is biased towards learning through experience.

Accepting this idea of experiential learning, one question remains: how is the experience to be gathered? Among experiential learning theories, an approach exercising an increasing influence on educators is called contextualized teaching and learning (CTL). Put simply, effective scaffolding employs components and features found within the learner's social context.

To further explain contextualization, we can return to the example of the Pythagorean Theorem. It is surmised that it first appeared in China in response to the social need to measure and divide up land. In Italy, however, the Pythagorean Theorem served as a political symbol of the dominance of the Roman Empire and was put to work in such vital areas as architecture. The universality of the learning object turns out to be trumped by its social context. In CTL, the social context of the learner is consciously built into the pedagogy and instruments of teaching. Contextualization as a way of contending with fundamental problems in education is described in a bulletin of the Community College Research Center "as an instructional approach that creates explicit connections between the teaching of reading, writing, or math on the one hand and instruction in a discipline area on the other, as, for example, when writing skills are taught with direct reference to topics covered in a history class" (Perin, 2011).

For a particularly broad vision of the global implications of contextualization today, the reader is urged to view a recent presentation of Paul Kim, CTO of Stanford University (Kim, 2011). Elsewhere, Kim and co-authors Talia and Olaciregui describe the ideas and wider aspirations of CTL this way:

Learning is hardly a discrete episode; rather it is an experience interwoven in our daily lives made up of the numerous tasks and stimulants we encounter. When we are faced with problems in various contexts, we often try to understand and respond with the cognitive and physical resources available within and around ourselves. Mobile learning provides the learner with frequent engagement opportunities in a non-time-intensive way, increasing the learning chances by allowing the learner to chip away at a large task once motivated [...] or work on incidental tasks requiring the right mood and occasion in everyday life. (Kim, Miranda, & Olaciregui, 2008)

The contextualization in CTL is not simply creating a narrative for a chunk of knowledge, i.e., a "story" problem, but finding a place in the every-day life of the learning for the grasping, application, and generalization from a given area of knowledge. For instance, grade-school students in the ecology portion of a class might work together to locate and compare solutions to the problem of delivering clean drinking water. This task has a different contextualization for learners in rural India and in urban Baltimore, and so would be approached accordingly by the teacher. The CTL approach is a step beyond laboratory experimentation into the everyday lives of the students.

The power of contextualized learning derives from the high level of engagement of the learner and the learner's ability to compare intuitive and researched approaches to the problem. It is shared, dynamic, and calls for the mutual involvement of educator and learner in the real or virtual manipulation of an object and the exploration of consequences or measurements of various arrangements of objects.

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As many have noticed, issues arise when CTL is seen as the entirety of learning methodology. First, there is the matter of efficiency; once set in motion, the learning process follows the logic of the situation. Whether or not this is adequate to assure coverage of key learning goals is only determinable after the fact. A more subtle issue is that the learner attends or, at any rate, takes part in the campus, classroom, or virtual community, all of which change over time. In fact, pedagogical technique, performance evaluation, and the relationship of perseverance in school to observed life-outcomes are all part of the learner's social context. In its earnest effort to emulate the environment without being part of it, CTL and social constructivist education open themselves to the logical question most frequently raised about experiential learning: if the learning is situative and if guidance is "gentle," i.e., facilitative, how can we be sure that objective goals are met?

In the evaluation of the Community College Research Center, "[a]ll of the outcomes of contextualization for basic skills achievement were positive." Based on a survey of current studies, the Research Center remarked on "college practitioners' enthusiasm about the value of contextualization," based on solid research primarily in K-12 schools. The survey recommends, among other things, "inquiry on the relation between the contextualization of basic skills instruction and subsequent course work, on the issue of dosage of contextualization, and on the nature of the dependent variable used in studies of contextualization."

The most remarkable takeaway from this survey is the apparent need for precision in contextualized learning. The continuing success of adaptive learning can help focus the "enthusiasm" of the practicing educator for methods that reach out to the learner in her given social context.

The Integration of Cognitive and Contextualized Learning

At the center of the development of LSI software and services is a systematic effort to integrate advanced cognitive and contextualized learning approaches; we find this combination to be the most effective and efficient approach to supporting education with collaborative tools. We call this approach Integrated Cognitive-Contextualized Learning (ICCL). Rather than its own theory, LSI elaborates ICCL by incorporating all the strength of ACT-R and adaptive learning within contextualized learning solutions. In doing so, LSI recognizes the need for emphasis on cognitive skill acquisition to render learning progress measurable. At the same time, LSI imposes no pre-conditions on educators in terms of pedagogy or teaching method, instead adapting its tools to the various teaching approaches and conditions of different institutions. What is unique about ICCL is that it deliberately invites the active involvement of practicing educators and educational theorists in the development of e-learning. In the course of this, LSI development and operations connect sound pedagogies of all sorts and educational institutions confronting the many issues they face, on the one hand, and the power and effectiveness of technology, databases, and Web communication, on the other. LSI's corporate vision encourages the union of the strengths of cognitive and social constructivist learning theory. The keys to this union are the **pedagogy/andragogy neutrality** and **broadened social context** of ICCL.

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The idea of integrating diverse tendencies is not original with LSI. For instance, in the paper cited above, Albert voices the aspirations of adaptive learning researchers.

The objectives of adaptivity [he says] include among others the adaptivity to the requirements of different learning cultures, to the teacher's and the student's aims and goals, to the student's *cultural background*, to their *preferences in human computer interaction*, to their *communication style* and *communication needs*, to their *cognitive and learning style*, to their actual (pre)knowledge, learning history and expertise. [emphasis added] (Albert & Mori)

These objectives are largely unmet. The adaptive learning programs, to be blunt, cannot emulate student background, any more than a human tutor can equip a student with a full curriculum of study. And among Perin's conclusions, we find that "the lack of rigorous research suggests that it is premature to invest substantial funds in a contextualization intervention at this time," despite the positive results of studies and enthusiasm of teachers.

LSI technologies do not separate the measure of knowledge acquisition from a dynamic human-machine interaction from the effort to make knowledge accessible (constructible) in the learner's social context. On the contrary, all of LSI's products and services rely upon the co-existence and cooperation of the live human educator. As learning tools, the services of LSI set educator enthusiasm free to guide effective classroom solutions. Learning continues outside the classroom, where online homework and content, tutoring support, and learning collaboration serve to continue the guidance of cognitive development *according to the parameters set by the educator*. All of the strengths of cognitive approaches are built into the technology, but its implementation *relies on the social context of the learner*.

What is Pedagogy Neutrality?

In building online learning solutions—both instructional environments and communication tools—LSI from its founding in 1995 opted out of debates about pedagogy¹. Early LSI developers recognized the value in the consistent use of a well-defined pedagogy. At the same time, being educators themselves, they knew that expert educators obtained good results in a variety of methods and that the "best" pedagogy had yet to be identified. The company took the stance of neutrally providing the tools tested and found effective by practicing educators to support their *disparate* pedagogies.

Today, pedagogy neutrality is recognized by various experts as its own necessity in the practical academics of running an educational enterprise. Satish Menon of the University of Phoenix, for instance, writes:

[W]e needed to move the implementation of learning platforms from the realm of using only best practices to using more Evidence-Based Practice (EBP) methodologies. At every step of the

¹ In this paper we follow the current fashion of treating pedagogy as the more general category of *methods of teaching*, as if it applies to both adults and children, i.e., both andragogy (Knowles, 1980) and the traditional notion of pedagogy as specific teaching method. While assuming the common-sense point of view that they are aspects of the same thing, we defer the analysis of the relationship between the two for another occasion.

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way, we needed to measure and quantify the types of activities (learning activities, content, assessments, instructional strategies) proven to be effective for the different types of learners (as defined by the learner attributes).

We call such a platform ‘**pedagogy-neutral**’, or ‘**andragogy-neutral**’ in the case of adult learners (Knowles 98), because this platform does not need to be hardwired to use any learning theory or instructional strategy – experimentation, data, and evidence will reveal the strategies appropriate for the types of learners and the topics they want to master... [W]e recognized early on that this is not an easy task; if it were, someone would have already mastered it!” (Menon, 2010)

In similar fashion, the founding team at LSI, including the present-day CTO, Dr. Yanmu Zhou and Senior Vice President Dr. Emil Moskona, built Web tools capable of deployment in any classroom or online situation. Examples of how pedagogy neutrality was built into LSI products include a focus on making the tools usable to any learner in possession of even a dial-up connection and a classroom-type interface where everything from elementary mathematical tools to the insertion of presentations and word-processing files is possible. Student and teacher enthusiasm for NetTutor® (the LSI online tutoring service) can also be attributed to the fact that the service, while addressed to furthering cognitive skill development, does so within the parameters set by the educator (Kersaint, Barber, Dogbey, & Kephart, 2011).

New Components of the Social Context in Online Education

In the translation of the materials of education to the Web, LSI undertook a revision of the understanding of social context as presented by constructivists. Both the way in which the learner is acquiring an education and the format in which learning goals are presented by our products expand the social context of the learner.

The learning context is an evolving whole, of which any course or pedagogy is but a part. The physical premises, the online connection, the culture of the school, and the expectations communicated to learners by their instructors are also components of the learning context. While these are found within and connected to the larger social environment, they define for the learner a real aspect of her life. We recognize this and find ways to reflect it in our products. Pedagogy neutrality means, first of all, allowing the learning context to control the culture of the learning tool, allowing for faculty input, and enabling change and redirection through the intervention of program administrators.

The social forum created by online interactivity forms a new and potent context for a learning community. Online tutoring, for example, provides an open access to an anonymous, presumably socially equal, academically expert partner in the learning process. It occupies the learner’s field of vision for the duration of a conference. It can also amplify the positive effect of intra-cohort reflection on the learning process with bulletin boards and so forth.

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The recognition of new aspects of the social context opens the way to connect cognitive and situative learning opportunities. At LSI, this is seen as the source of the educational progress witnessed through online education.

The Unity of the Cognitive and Social Views of Learning

Products built on the principle ICCL are inherently integrated contextualization tools. That is, they allow for the integration of review into the course itself. They are cognitively robust, allowing for firm conclusions about the progress of the participants. These two sides of an ICCL tool are linked by an invitation for the incorporation of teacher pedagogy and local (institutional or regional) standards. The ideal ICCL tool presents an interface that makes two aspects of learning obvious and easy-to-understand: first, everything about the interface appeals to the senses and grapho-motor skills of the user in order to leverage the familiarity, comfort, and immersive quality of online communication to achieve cognitive attainments; secondly, the interface takes on the images and terminology of the institution and provides transparent access to its resources where appropriate.

The fundamentals of ICCL are not computer-specific. Instead, they use the requirement of emulating face-to-face interaction on the Web to create a yardstick for ways to easily and naturally facilitate discussion and other learning interactions. Among the distinct products that incorporate ICCL principles are:

1. An online classroom encompassing live interaction with an unlimited number of participants and moderated by a session leader; multiple functionalities allow all participants to share in both synchronous and asynchronous forms
2. Adaptive learning techniques in homework systems amplified by a multi-level and multi-tolerance set-up procedure to implement learning context
3. Online content based on taxonomies incorporating not simply Bloom's general image of learning, but local (institution-specific or regional) requirements
4. A 24/7 on-demand online tutoring service incorporating the Socratic Method as a means of contextualization, coordinating cognitive and learning context-centered elements through an elaborate scheme of institutional control over the tutor-learner interaction

Cognitive contextualization is reflected as well in the operationalization of distance education. When authors and tutors alike are subject-matter experts, capable of generating materials and creating learning contexts favorable to achievement, cognitive and contextual component come together. An example is found in LSI, a company that not only provides all of the services and products mentioned above. In addition, special projects show how this can be extended to provide unanticipated educational solutions. For instance, tutors also create grading recommendation for writing students in virtual high schools. In this context, the teachers own the grades themselves; a rubric is provided to secure cognitive advancement, and the teacher-tutor partnership is highly collaborative.

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Online content developed by LSI's authors plays a role in individual curricula and supplies part of the content for the most widely-used of the current online homework systems. Disparate media are used, from videos to a completely articulated algorithmic question authoring and evaluation system.

Principles of ICCL

In short, ICCL is a fully consistent constructivist learning approach. Its principles are few and easy to understand and to apply. They are as follows:

- 1) All learning takes place through the individual's acquisition of discrete chunks of knowledge. Taxonomies, which range from Bloom's early efforts to the Common Core perspective today, provide cognitive skills acquisition schema that both measure and guide this process.
- 2) All learning takes place in an ever-changing social environment. Community, culture, learning environment, and online environment must match and be incorporated by effective learning tools.
- 3) The practicing educator leads this process. The pedagogy or andragogy expressed in the support of education needs to match that of the practicing educator.
- 4) Each learner comes to the project of learning from a specific social context. Questions of which learning style to use are best determined in practice, whereas learning goals are best set ahead of time.

ICCL Practice and Results at LSI

The application of ICCL permeates the LSI operations. The use of the ICCL-based products of LSI is shown to promote student success through its insistence upon and facilitation of learning as the attainment of concrete cognitive goals by engaged individuals in a socialized environment.

High-quality field trials show that students who use tools based on the cognitive learning principles adopted by LSI:

- Demonstrate up to 85% better performance on assessments of complex mathematical problem solving and thinking.
- Achieve 15-25% better scores on the SAT and other aptitude tests (Koedinger, Anderson, Hadley, & Mark, 1997).
- Persist and successfully complete core courses 25% more frequently (Kersaint, Barber, Dogbey, & Kephart, 2011).

In addition, LSI's contextualized learning products and services are constantly improving through a network of advisory boards and academic researchers. The company incorporates the latest research in neurological science and in learner motivation.

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Change and complexity are the only constants in a learner's life; contextual learning allows educators to reflect these changes and to leverage technologies and resources to meet new needs and imperatives. The products and services of LSI empower students, giving them the ability to apply the subject matter to improve their performance. We facilitate the construction of meaning from familiar events, which motivates learners to make connections between the knowledge being gained and its relevance to their lives.

Based on key educational theories and themes, our contextual tools—content services, online tutoring, and learning software—share these common characteristics:

- They are socially shared.
- They provide specialized tools that students use to shape their cognitive abilities.
- They facilitate active learning with the use of objects and events.
- They are situation specific.

As leaders in contextual content services, our subject matter experts create new content or automate existing content to meet the needs of a specific client or student. As pioneers in online tutoring, we train our online tutors to draw learners into compelling contextual learning experiences. All of our products are designed to contextualize the learning process to ensure that end users acquire the information and skills they need to succeed.

Research-based contextualized learning leads to important advantages for institutions using LSI tools and services. For instance, the development of contextualized course content is rarely a matter of starting from scratch. LSI understands this and evaluates existing content, repurposing what is still useful for new markets or platforms and complementing other portions with ready-made tools. Moreover, independent research has verified that this approach pays off in real educational terms.

Internal speech, that vital element analyzed by Vygotsky, is externalized and preserved through the operation of online tutoring. In the NetTutor Online Tutoring Service, tutors not only employ the Socratic Method but also work in a shared environment with other tutors. This confronts them with the continuing task of understanding where others come from and how to contextualize learning. The Socratic Method is not used solely to assist with cognitive accomplishment but also to determine and contextualize the construction of knowledge by learners. This is keenly empowering for learners and explains, in part, the remarkable increase in perseverance observed with the use of NetTutor. In a matched control group study at the University of South Florida, it was shown that comparable groups of Algebra student performed equivalently, while 25% more of the students offered online tutoring persisted in the class. Over 90% of the students who selected to use the tutoring service persisted and these students received statistically better grades than their non-using counterparts (Kersaint, Barber, Dogbey, & Kephart).

The WorldWideWhiteboard® of LSI—the ground-breaking user interface for educational collaboration online – has been tested repeatedly and has proven to assist in key cognitive areas in some of the courses student find most challenging (Smith & Klein, 2004). Serving the concrete student context has been shown to be a key strength of LSI technology (Thomas, Li, Knott, & Li, 2006). A new LSI product,

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bringing together the live online interaction aspect with a body of online content for self-development or ancillary to a course, is being tested throughout the US. This product, called MyAcademicWorkshop™, directly brings contextualization and cognitive learning together in a single technology.

The Future of ICCL Research

The development of ICCL, bringing together the best in cognitive and social constructivist thinking through a pedagogy neutral platform, requires the participation of new layers of leaders in education. For this reason, LSI welcomes the commentary, criticism, and participation of academics. Simply put, modern education techniques do not develop themselves; they require an interdisciplinary approach capturing the best in computer science, psychology, education, neurology, and many other sciences.

LSI is committed to the creation and reinforcement of its alliance with educators and researchers. The key element that has encouraged the combination of proven cognitive learning technique with the comprehensiveness of contextualized learning is the effort at realizing successful learning solutions in the online environment.

The benefits of this alliance between developers of software and experts in learning theory to this and coming generations of learners are plain. They have been shown, in outline, in the research that has already been conducted. It remains to direct our inquiries towards the process of learning in various environments, towards the affordances of on- and off-line and blended interactions, and towards specific features and measures that contextualize learning. We welcome all academics willing to take part in this research to contact us, to set up investigations, and to write about their experiences with online tools and their views about learning theory.

In the meantime, the ICCL has proven to increase retention rates and student perseverance in core courses, while enabling significantly greater learning achievement. Link-Systems International will proceed to design new software, update and maintain existing installations, and support the distance learning efforts of institutions and their industrial collaborators starting from the ICCL point of view. We will be asking—and encourage all educators to consider—these questions: how can collaboration and content-related software give a more authentic, contextualized experience? How can we encourage, measure, and provide evidence of the attainment of measurable cognitive achievements?

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About Link-Systems International, Inc.

LSI Mission Statement

Link-Systems International is the leader in providing integrated technology and service solutions to educators in order to improve the quality of education and training, ensure student success and retention, and provide affordable education to students, workers, and their families.

Research-based Approach

Link-Systems International (LSI) employs Integrated Cognitive-Contextualized Learning (ICCL) in order to deliver research-proven online learning products and services that are based on the latest developments in learning theory. Educators work hard to engage students and to help them reach their learning goals; we offer theory and practice to supply educational technology in support of that work. LSI has recognized the unity of two important arms of constructivist learning theory—the measurement of self-achieved cognitive advances against agreed-upon standards and the contextualization of learning to create learning initiatives for the active learner.

Over the years, LSI has accumulated a wealth of experience with educators seeking to engage their students through authentic and involving learning experiences. At the same time, institutions and innovators sought new ways to measure and reinforce concrete cognitive advances. According to ICCL, these are simply two sides of the same experience: implementation of online learning tools enables both the delivery of contextualized content and the verification of learning achievement.

The application of ICCL has practical results for LSI, whose products and services are all based on the theory. LSI uses ICCL to customize its products and services to meet the specific needs of its learning institutions and their partners. At the same time, all of its products and services make educational achievement measurable to ensure learning success while peer-reviewed research supports their effectiveness. The partnerships between educators and LSI are helping to define the new face of quality learning in the digital age.

Our Company

LSI is a privately-held company that has been dedicated to student success and student retention in K-12 education, higher education, and workforce development education since 1995. We specialize in technology development, online tutoring services, and content services.

Our core technologies include a flexible online tutoring/teaching platform, an online grade book, an online algorithm engine with metadata and workflow capabilities, and an online business intelligence/data mining technology designed to provide real-time alerts regarding student/school/teacher performance, student attendance, and other metrics.

Our core services include content development, consulting, and online tutoring through our NetTutor® brand.

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Our customers include K-12 publishers, higher education publishers, virtual high schools, higher education institutions, technology companies, and joint programs dedicated to providing online educational content to members of organized labor and their families.

We are located in Tampa, Florida, a few miles from the University of South Florida, which has excellent engineering, computer science and mathematics programs, providing LSI many of its employees.

Launched in 1995, LSI has created several unique and powerful technologies, which facilitate the sharing of content over the Internet. We specialize in mathematics, technical and scientific content, the most critical types of online content with respect to student success, and the most difficult to share online.

Student Success and Student Retention

Today, LSI is recognized by a variety of publishers and educational institutions not only for its high-quality work and dedication to meeting commitments, but also for its unique ability to develop digital strategies that are tailored to the needs of its customers.

Our partners and customers have come to value and trust LSI because we are the only company that offers a complete suite of interoperable solutions that address the entire life cycle of the student, with an overt focus on the bottom line: student success and student retention. That student life cycle includes:

- * Online Assessment and Placement
- * Content Authoring
- * Content Recovery, Content Management and Metadata Management
- * Online Teaching, Collaboration, and Tutoring
- * Online Homework and Testing
- * Online Grade book Technologies
- * Online Real-Time Performance Monitoring and Intervention

Through a relationship with LSI, educators acquire the ability to construct a holistic approach to student success and student retention.

Corporate Executive Team

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About Academic Research at LSI

We are enthusiastic about the commitment of institutions and academics to the use of technology with proven benefits to their students. If you would like to write about the impact of Web-based technology, please let us know. We encourage educational research and will work with you and your staff to develop scientific studies into the relationship of the online learning experience to successful student outcomes. Please contact our Academic Research Department.

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