Understanding the Needs of Student Users of Digital Smithsonian Resources (vol. 1 of 7)

An Analysis of Existing Literature and Research

Characteristics of Digital Learning Content, Pedagogies, and Platforms That Support Young Learners

Prepared for
The Smithsonian Center for Learning and Digital Access

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NAVIGATION NORTH

Smithsonian Center for Learning and Digital Access

The Smithsonian Center for Learning and Digital Access (SCLDA) uses all the Smithsonian offers to empower learners to explore their interests and collaborate with others to bring ideas to life. The organization creates models and methods that make the Smithsonian a Learning Laboratory for everyone. Guided by the Smithsonian's mission of the increase and diffusion of knowledge, SCLDA was established to re-imagine and ultimately reinvent the way students, teachers, and lifelong learners interact with and use the Smithsonian's resources in the 21st century. Recognizing most will never visit Smithsonian museums, SCLDA set out to identify how it might best enrich education by making Smithsonian experts and collections accessible to everyone regardless of where they live.

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Certainly, students without access to technology-based environments and opportunities will be tremendously disadvantaged in efforts to organize and plan their intellectual pursuits and achieve in academic endeavors.

Learning Technology Effectiveness; U.S. Department of Education, Office of Educational Technology [1]

If teachers are no longer bound to the structure of traditional textbooks, they will have more freedom to incorporate creative lessons and adapt the sequencing and style of their lessons to their students' needs.

Open Educational Resources;
Advancing Widespread Adoption to Improve Instruction and Learning[2]

We've had over 50 years of theory and practice, research and development into how computers can reshape education. Yet we're still just not that good at building or implementing technology in the service of transforming teaching and learning. . . . Part of the problem is that many ed-tech products have been developed and then in turn purchased without input from or support for teachers (let alone students).

Audrey Watters - Hack Education[3]

[1] "Learning Technology Effectiveness | Office of Educational Technology." 2014. Accessed May 31. 2016. <http://tech.ed.gov/learning-technology-effectiveness/>
[2] "Open Educational Resources - Hewlett Foundation." 2015. Accessed May 31, 2016. <http://www.hewlett.org/sites/default/files/Open_Educational_Resources_December_2015.pdf>
[3] "Ed-Tech Guide." 2012. Accessed August 30, 2016. <http://guide.hackeducation.com/>

Background

Since 2011, the Smithsonian Center for Learning and Digital Access (SCLDA) has strived to better understand and address the needs of educators utilizing digital assets through a variety of research and user testing studies that have led to the creation of a new digital learning platform, the Smithsonian Learning Lab (SLL), launched in June 2016[4]. The Smithsonian Learning Lab provides access to the digital resources from across the Smithsonian's 19 museums, 9 major research centers, and the National Zoo, to be used as real-world learning experiences. With a repository of over 1.6 million objects and a new resource being digitized and added every 6 seconds, the Learning Lab provides specialized tools to aid in the discovery and creative use of its rich digital materials. For students using the Learning Lab, it is designed to aid in building lasting knowledge and critical skills that take learners from simply finding resources to thoughtful selection, examination, organization, and creation of new resources.

The SLL, as it currently exists, was largely informed by the input and practice of diverse and effective educators.[5] Therefore the goal of this Literature Review, as a piece of a larger research effort, *Understanding the Needs of Student Users of Digital Smithsonian Resources,* focuses on published research, studies, reports, and articles targeting student use of digitally supported learning environments and tools. While not intended to be a mere validation of SLL's features, the design for this review and summary report is to lend additional insight into how digital systems, tools, pedagogy and content, can be adapted to better meet students' learning needs. As educational psychologist Paul A. Kirschner[6] points out, "If the student is viewed as the end user… participatory design needs to include a more direct participation/contribution of the student in the design of (technology enhanced) learning environments". The overall project will assimilate the findings of this Literature Review along with an environmental scan of widely used platforms and a series of field observations. Our hope is to address some key questions around methods or requirements for enhancing student motivation and engagement with digital content and tools.

1. What are the ways that students engage with digital content in academic settings?
2. What are the motivations for student use of digital content?
3. What are the interface requirements/scaffolds needed to enable and enhance student engagement with rich digital resources?

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[4] Milligan, D., and M. Wadman, M. 2015. "From Physical to Digital: Recent Research into the Discovery, Analysis . . ." <http://mw2015.museumsandtheweb.com/paper/from-physical-to-digital-recent-research-into-the-discovery-analysis-and-use-of-museums-resources-by-classroom-educators-and-students/>

[5] "smithsonian-digital-learning - Teacher Toolkit (Research Findings)." 2013. 28 Sep. 2016 <https://smithsonian-digital-learning.wikispaces.com/Teacher+Toolkit+(Research+Findings)>

[6] Kirschner, P. A. 2015. "Do We Need Teachers as Designers of Technology-Enhanced Learning?" <http://link.springer.com/article/10.1007/s11251-015-9346-9>

Methodology

A general scan was conducted focusing on relevant research, reports, and articles targeting online learning and use of digital content for both formal and informal learning. However, given that the project has identified classroom teachers as an initial, primary audience in which to gain access to young learners, priority was given to studies, observations, use-cases, and derivative findings that posed the greatest potential applicability to students operating in more formal, structured environments, such as classrooms.

The age-range targeted for this review is 13-17 year olds as they can actively consent to having personal accounts that make use of both online learning systems and social media platforms.[7] While soliciting research, reports, and case studies, it is clear that both researchers and practitioners see technology-supported learning as a constantly evolving field of study in need of more detailed examination.[8] In exploring the role of technology in learning, challenges exist in organizing fairly disparate research into coherent and comprehensive categories that persist across a growing array of implementation models, populations, and constantly changing technology products and systems.[9] Therefore, we chose a set of broad categories in which to frame the current state of K–12 online supported learning based on the review of relevant literature. This report distills this selected research into the categories of **content**, **pedagogy**, and **platform**.

We will use the following descriptions from the International Association for K–12 Online Learning's student-centered TPAC (Technology; People, Pedagogy, Professional Development; Assessment; and Online Content) framework,[10] to organize the following sections of the report:

> **Content**
> Includes the types of learning resources and existing content made available to students through the web-based learning system in addition to the content, resources, and assessments that can be generated by educators with the system's on-board authoring and uploading tools.

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[7] "Children's Online Privacy Protection Rule." 2011. Federal Register 76: 187.
[8] Roblyer, M. D. 2005. "Educational Technology Research That Makes a Difference: Series Introduction." *Contemporary Issues in Technology and Teacher Education* 5.2.
[9] Winn, W. 2002. *Educational Psychology Review* 14: 331. doi:10.1023/A:1016068530070
[10] "iNACOL New Learning Models Vision - iNACOL." 2013. Accessed June 7, 2016. <http://www.inacol.org/wp-content/uploads/2013/11/iNACOL-New-Learning-Models-Vision-October-2013.pdf>

Pedagogy
Pertains to the methods in which the system is set to organize curriculum, sequence instruction, and scaffold existing descriptive content and user-generated content in relation to resources, assessment, and learner access.

Platform
Refers to the web-based learning system as defined by the architecture, user experience and interface design, and tools used to navigate, search, store, annotate, author, collaborate, communicate, and share digital learning resources and experiences.

Content Findings Review

Includes the types of learning resources and existing content made available to students through the system in addition to the content, resources, and assessments that can be generated by educators with the system authoring and uploading tools.

Organizing Content and Media to Reduce Cognitive Load

A common concern raised in many research articles focusing on the development of media-rich, digital learning content focuses on the potential of cognitive overload for the learner. Sweller's Cognitive Load Theory,[11] as it applies to multimedia-based content, is an oft-cited concept as related to the structure of digital learning environments and content.[12] Cognitive load theory is focused on examining the learning of complex cognitive tasks, where learners are asked to navigate a number of information elements and their interactions that need to be processed simultaneously before meaningful learning can commence.[13] In order to not overload a learner's working memory, findings show that intentional layout and positioning of content and related objects or supporting visual aids and images are particularly important to ensure that a learner's focus and comprehension of content is supported and not disrupted.[14] In looking at the application of multimedia to narrative content, it was found that images including basic animated movements and zooming can help increase student comprehension when those effects are intentionally and closely aligned to the content they support.[15] Additionally, there are direct correlations to deeper comprehension and helping anchor new concepts to existing knowledge when images and content are interdependent and simultaneously displayed.[16] The findings suggest that when students do not need to hold the oral narration and the illustration in working memory, the cognitive load they face is reduced.[17]

Therefore, nonverbal information such as animated visualizations, background sounds, and music, aid students' comprehension only when it is directly related to and supportive of the

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[11] Sweller, J. 1988. "Cognitive Load During Problem Solving: Effects on Learning." *Cognitive Science* 12: 257–285

[12] Bruenken, R., and J. Plass and D. Leutner. 2003. "Direct Measurement of Cognitive Load in Multimedia Learning." *Educational Psychologist* 38(1): 53–61.

[13] Paas, F., and A. Renkl and J. Sweller. 2004. *Instructional Science* 32: 1.

[14] Mayer, Richard, and Roxana Moreno. 2003. "Nine Ways to Reduce Cognitive Load in Multimedia Learning." *Educational Psychologist* 38(1): 43–52.

[15] Takacs, Zsofia K., and Elise K. Swart and Adriana G, Bus. 2015. "Benefits and Pitfalls of Multimedia and Interactive Features in Technology-Enhanced Storybooks: A Meta-Analysis." 2015. *Review of Educational Research* 85.4: 698-739.

[16] Martinec, Radan, and Andrew Salway. 2005. "A System for Image-Text Relations in New (and Old) Media."

[17] Mayer, Richard E., and Richard B. Anderson. 1992. "The Instructive Animation: Helping Students Build Connections Between Words and Pictures in Multimedia Learning." *Journal of Educational Psychology.* 84.4: 444.

content.[18] Creating stronger matches between verbal and nonverbal information in multimedia content supports learning outcomes.[19] Instead of increasing cognitive overload, nonverbal information that is tightly aligned to the content topic is beneficial for those students with limited vocabulary proficiency and does not diminish the learning of those with expected vocabulary proficiency.[20]

In addition to addressing disconnects between content and nonverbal supporting media, asking students to navigate several pages in order to complete a task lends to a drop in learner performance.[21] It was found that a simple digital reading task becomes more difficult when the information needed to complete it is not immediately visible. Conversely, in tasks where demands for navigation are minimal because the relevant information can be readily accessed, the most important predictor of success is whether the student performed the few relevant steps that were required.[22] In examining the role of technology, digital tools, and resources that support more complex learning models, Barab and Leuhmann observed some key challenges that technology could support.

> One of these challenges involves connecting students with a rich and diverse set of resources including media such as video, books, journals, etc., or collaborators such as peers or experts. Another challenge is to provide the process scaffolding or support students need as they engage in authentic science activities such as collecting evidence, testing hypotheses, or formulating arguments.[23]

These strategies help students more quickly access rich content and media and in turn reduces the extraneous cognitive load not necessary to the specific learning.[24]

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[18] Moreno, Roxana, and Richard Mayer. 1999. “Cognitive Principles of Multimedia Learning: The Role of Modality and Contiguity.” *Journal of Educational Psychology* 91.2: 358.
[19] Verhallen, Maria, and Adriana G Bus and Maria T de Jong. 2006. “The Promise of Multimedia Stories for Kindergarten Children at Risk.” *Journal of Educational Psychology.* 98.2: 410.
[20] Silverman, Rebecca, and Sara Hines. 2009. “The Effects of Multimedia-Enhanced Instruction on the Vocabulary of English-Language Learners and Non-English-Language Learners in Pre-Kindergarten Through Second Grade.” *Journal of Educational Psychology.* 101.2: 305.
[21] OECD *Students, Computers and Learning: Making the Connection*, 2015. Paris: OECD Publishing. doi: http://dx.doi.org/10.1787/9789264239555-en
[22] "Students, Computers and Learning: Making the Connection." 2015. Accessed June 2016, <http://www.oecd-ilibrary.org/students-computers-and-learning_5jrxqsqd92tc.pdf>
[23] Barab, Sasha Alexander, and April Lynn Luehmann. 2003. “Building Sustainable Science Curriculum: Acknowledging and Accommodating Local Adaptation.” *Science Education* 87.4: 454-467.
[24] De Jong, T. 2010. “Cognitive Load Theory, Educational Research, and Instructional Design: Some Food for Thought.” *Instructional Science* 38: 105.

Transitioning Low-Level Cognitive Activities to Deeper, Inquiry-Based Activities

During the early evolution of internet-based instructional development, distance-education researchers such as Johnson and Aragon[25] warned that, while online content presented opportunities for more collaborative, project-based, and situational learning, designers were largely ignoring the qualities of the web, and opting to adopt traditional models of education that merely transferred information from instructor to learner with rote exam activities. Deeper engagement calls for online learners to interact with the content to apply, analyze, synthesize, evaluate, and reflect on what they learn[26] in order to move to higher levels of processing. These higher cognitive levels of processing create more associations to and between existing knowledge and are more readily committed to long-term memory.[27] As an extension to this research, Zhang, et al.[28] examined online inquiry activities that involved rich content learning and those that did not. Tasks that did not engage students in rich content learning were termed low-level cognitive activities because they did not require deep thinking or engagement with specific content being examined by the students.

In relation to the nature of effective online activities, Anderson[29] identifies the wealth of potential diversity the web brings to online content development, and the need to engage and utilize that wealth.

> The task of the online course designer and teacher is to choose, adapt, and perfect (through feedback, assessment, and reflection) educational activities that maximize the affordances of the web. In doing so, they create learning-, knowledge-, assessment-, and community-centered educational experiences that result in high levels of learning by all participants.

When activities that involve group interaction are assessed, Garrison and Cleveland-Innes warn of the risks in assigning too much value to the assumed benefits of communities of learners (based solely on the volume of their interactions and repeated low-level tasks).[30] Their studies distinguish some key differences between social communities focusing on peer interaction, and communities of inquiry that, "... integrate[s] cognitive, social, and teaching elements that

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[25] Johnson, Scott D., and Steven R. Aragon. 2005. "An Instructional Strategy Framework for Online Learning Environments." <http://ldt.stanford.edu/~educ39105/paul/articles_2005/An%20Instructional%20Strategy%20Framewok%20for%20online%20instruction_Johnson_Aragon.pdf>

[26] Berge, Z. L. 2002. "Active, Interactive, and Reflective Learning." *The Quarterly Review of Distance Education* 3(2): 181-190.

[27] Ally, M. 2004. "Foundations of Educational Theory for Online Learning." In T. A. Anderson and F. Elloumi, eds. *Theory and Practice of Online Learning,* pp. 3-31. Athabasca, Alberta, Canada: Athabasca University.

[28] Zhang, Meilan, and Chris Quintana. 2012. "Scaffolding Strategies for Supporting Middle School Students' Online Inquiry Processes." *Computers & Education* 58.1: 181-196.

[29] Anderson, Terry. 2008. "Towards a Theory of Online Learning." *Theory and Practice of Online Learning* 2: 15-44.

[30] Garrison, Randy, and Martha Cleveland-Innes. 2005. "Facilitating Cognitive Presence in Online Learning: Interaction Is Not Enough." *The American Journal of Distance Education* 19.3: 133-148.

go beyond social exchanges and low-level cognitive interaction." A community of inquiry that deliberately supports learning deemphasizes the quantitative measurement of social interactions and instead frames social interaction as a qualitative support of the cognitive and teaching presence within the digital learning environment. Staging the content to present a complex problem or a new concept, coupled with actions asking learners to share their resolutions, can trigger intentional discourse and shared analysis that promote social learning. [31]

As Azevedo[32] points out in his review of literature and his own studies, moving students beyond declarative knowledge exercises toward deeper, inquiry-based activities requires scaffolding. Scaffolding is the process of creating intermediary instructional steps and guidance to enable students to carry out a task or grasp a concept they previously would not have been able to on their own.[33] While soft scaffolds typically are dynamic and include situation-specific aids as provided by a teacher as a pedagogical element, hard scaffolds are static supports that can be anticipated and planned in advance based upon typical student difficulties with a task and can be embedded within multimedia.[34] As such, scaffolding in an online environment can have four unique elements:

- diagnosis of student's existing knowledge,
- calibrated support related to student's needs,
- fading support as student acquires more skills and knowledge, and
- individualization which transitions responsibility for competence to each student.

When implemented with students, this type of explicit scaffolding can move them from simple procedural activities into deeper, self-guided, reflective learning.[35]

Content: Summary

The literature in this section references the importance of strategically aligning content topic and concepts with accompanying media. Additionally, minimizing the number of steps students must take when moving from the learning content to a task dependent upon that content supports student success. Content designed to engage students in deeper inquiry with intentional collaboration that minimizes low-cognition tasks affords students better

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[31] Swan, K., and Randy Garrison and J. Richardson. 2009. "A Constructivist Approach to Online Learning: The Community of Inquiry Framework."
[32] Azevedo, Roger, and Allyson F. Hadwin. 2005. "Scaffolding Self-Regulated Learning and Metacognition–Implications for the Design of Computer-Based Scaffolds." *Instructional Science* 33.5: 367-79.
[33] Verenikina, I., 2008. "Scaffolding and Learning: Its Role in Nurturing New Learners." *Learning and the Learner.* University of Wollongong <http://ro.uow.edu.au/cgi/viewcontent.cgi?article=1043&context=edupapers>
[34] Brush, Thomas, and John Saye. "A Summary of Research Exploring Hard and Soft Scaffolding for Teachers and Students Using a Multimedia Supported Learning Environment."
[35] Sharma, P., and M. J. Hannafin. 2007. "Scaffolding in Technology-Enhanced Learning Environments." *Interactive Learning Environments* 15: 27–46.

opportunities to learn, and can be guided by built-in (as will be discussed in the following section) intermediary instructional steps that move learners incrementally beyond their current knowledge base.

Pedagogy Findings Review

Pertains to the methods in which the system is set to organize curriculum, sequence instruction and scaffold existing descriptive content and user-generated content in relation to resources, assessment, and learner access.

Supporting Deep, Online Inquiry

Welch[36] identifies the process of inquiry as one in which learners are free to formulate questions, design experiments or activities to solve problems, and then engage in knowledge building through self-selected or facilitated experiences. DuVall[37] points out that inquiry is born from instructional design that is comfortable with students asking why and how, and that anticipates these questions as a framing for the curriculum.

Role of metacognitive supports in online learning environments

The support of metacognitive skills is critical to learner inquiry and problem-solving success within online learning environments.[38] In general, these types of reflective activities can be broken down into metacognitive knowledge and metacognitive regulation. Metacognitive knowledge involves a learner's understanding of his or her own cognitive strengths and weaknesses, knowledge of the task, and strategies for approaching the learning. Metacognitive regulation involves planning the tasks required to solve a problem, monitoring progress, and re-calibrating one's learning approach throughout the process of executing the tasks.[39]

Since educators typically rely on supporting learner metacognitive processes directly as part of ongoing monitoring, use of open-ended questions, and dialogue with students on inherent confusion and linkage with prior knowledge,[40] many online learning systems emphasize content structure and the learner's movement through cognitive activities. When engaging students in online learning independent from the direct guidance of a teacher, it is important to provide explanations for how tasks should be approached and engaged, as well as explicit criteria for defining when tasks are accomplished.[41] When this structure is not present, students operating in online environments are left to devise a largely unplanned or unexamined path to carry out

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[36] Welch, Wayne W., et al. 1981. "The Role of Inquiry in Science Education: Analysis and Recommendations." *Sci. Ed.* 65.1: 33-50.
[37] DuVall, R. 2001. "Cultivating Curiosity with Comfort: Skills for Inquiry-Based Teaching." *Primary Voices K-6* 10(1): 33-37.
[38] Kapa, Esther. 2007. "Transfer from Structured to Open-Ended Problem Solving in a Computerized Metacognitive Environment." *Learning and Instruction* 17.6: 688-707.
[39] Ford, J. Kevin et al. "Relationships of Goal Orientation, Metacognitive Activity, and Practice Strategies with Learning Outcomes and Transfer." 1998. *Journal of applied psychology* 83.2: 218.
[40] Chick, Nancy. "Metacognition: Putting Metacognition into Practice." <https://cft.vanderbilt.edu/guides-sub-pages/metacognition/>
[41] Sandberg, Jacobijn, and Yvonne Barnard. 1997. "Deep Learning Is Difficult." *Instructional Science* 25.1: 15-36.

their online inquiry process due to a natural tendency to get things done with minimal cognitive effort or because they lack these metacognitive planning and monitoring skills.[42]

The Role of Social Interaction, Communication, and Community

Many studies have struggled to correlate online learning design elements to learning gains as isolated from other factors. In Kreijn's extensive review of research focusing on Computer Supported Collaborative Learning (CSCL) environments, he identifies the core issue when assessing cooperative or collaborative learning environments.

> There seems to be an almost irresolvable discussion as to what 'collaborative' and 'cooperative' learning are and what their differences/commonalities are. This is confounded by the fact that educational researchers often have different purposes,goals, and perspectives (e.g. whether the terms denote processes or states) which prohibit a clear distinction between the two approaches to group learning.[43]

As related to digital learning, some studies elect to include data on student engagement, retention, and enjoyment, as measured through satisfaction surveys, completion rates, and other qualitative metrics. In relation to these indicators, it has been widely established through a number of meta-analyses of existing research[44] that a primary predictor of academic retention is the relative amount of communication activities integrated into online coursework and learning activities. Research has shown that these activities can be supported within a learning task that promotes "epistemic fluency," which Morrison and Collins define as ''the ability to identify and use different ways of knowing, to understand their different forms of expression and evaluation, and to take the perspectives of others who are operating within a different epistemic framework."[45] Simply put, these tasks include describing, explaining, predicting, arguing, critiquing, evaluating, explicating, and defining—all in the context of a discourse within the community of learners and under the guidance of the teacher and/or the course structure.

Balancing cognition and social learning activities

Early online learning system and tool design primarily focused on content authoring, distribution tools, and assessment instruments aimed at the individual learner.[46] But as Beldarrain asserts, "The added control and interaction provided to learners using technology

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[42] Zhang, Meilan, and Chris Quintana. 2012. "Scaffolding Strategies for Supporting Middle School Students' Online Inquiry Processes." *Computers & Education* 58.1: 181-196.
[43] Kreijns, Karel, and Paul A. Kirschner and Wim Jochems. 2003. "Identifying the Pitfalls for Social Interaction in Computer-Supported Collaborative Learning Environments: A Review of the Research." *Computers in Human Behavior* 19.3: 335-353.
[44] Muilenburg, Lin Y., and Zane L. Berge. 2005. "Student Barriers to Online Learning: A Factor Analytic Study." *Distance Education* 26.1: 29-48.
[45] Morrison, Donald, and Allan Collins. 1996. "Epistemic Fluency and Constructivist Learning Environments." *Constructivist Learning Environments* 107-119.
[46] Cross, Jay. 2004. "An Informal History of eLearning" *On the Horizon* 12: 103-110.

tools may help tap into a student's expertise, and promote collaboration through peer-to-peer mentoring, team work, and other strategies."[47] Initial online learning constructs that almost exclusively supported rote consumption of information rather than integrating social learning activities (while social media, which had been successful in engaging the interest of youth) failed to capitalize on social interaction and communication enabled by the web.[48]

Best practices now encourage teachers and researchers to focus on the social elements of learning to provide balance to raw knowledge acquisition that typically dominates the online learning process.[49] In one study, students' level of enjoyment was predominantly commensurate with the amount of social interactivity designed and supported in the online learning activities and environment. Subsequently, those students lacking confidence with online social interaction in general or lack of understanding on how to best use the tools to support online social interaction cited these gaps as the most significant barriers to their success.[50]

Beyond learner enjoyment and satisfaction, there is growing evidence that the steps necessary for measurable learning gains occur directly or are substantially supported by student-to-peer and student-to-instructor exchanges.[51] Of particular interest is the process of having students openly articulate their learning by explaining a concept they are studying or describing a resource or object they are examining to a peer or teacher.[52] However, remote online learning groups using digital environments as their sole means of connecting, often lack the types of intentional, and free-form social interaction needed to support these meaningful dialogues. Even with a growing list of specific collaboration tools and community interactivity features surfacing in various digital learning environments (such as instantaneous messaging, or real-time peer co-authoring), there appear to be at least two common obstacles to social interaction in online learning environments: taking social interaction for granted (assuming it will naturally occur without guidance merely because the tools exist), and restricting social interaction to just those activities and collaboration that are tightly aligned to the execution of the learning task.[53]

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[47] Beldarrain, Yoany. 2006. "Distance Education Trends: Integrating New Technologies to Foster Student Interaction and Collaboration." *Distance Education* 27: 139-153.
[48] Arbaugh, J. B. 2014. "What Might Online Delivery Teach Us About Blended Management Education? Prior Perspectives and Future Directions." *Journal of Management Education* 38.6: 784-817.
[49] Rienties, Bart, and Lisette Toetenel. 2016. "The Impact of Learning Design on Student Behaviour, Satisfaction and Performance: A Cross-Institutional Comparison Across 151 Modules." *Computers in Human Behavior* 60: 333-341.
[50] Muilenburg, Lin Y., and Zane L. Berge. 2005. "Student Barriers to Online Learning: A Factor Analytic Study." *Distance Education* 26.1: 29-48.
[51] Van der Linden, Jos, et al. 2000. "Collaborative Learning." *New Learning* 37-54.
[52] O'Donnell, Angela M., and Cindy E. Hmelo-Silver and Gijsbert Erkens. 2013. *Collaborative Learning, Reasoning, and Technology*. New York: Routledge.
[53] Kreijns, Karel, and Paul A. Kirschner and Wim Jochems. 2003. "Identifying the Pitfalls for Social Interaction in Computer-Supported Collaborative Learning Environments: A Review of the Research." *Computers in Human Behavior* 19.3: 335-353.

Social-constructivist activities increase overall learner engagement
Honebein and Duffy[54] found that the design of learning activities strongly influences how students engaged within an online learning management system (LMS). Particularly in social constructivist environments where students are guided to access prior knowledge and apply it to new concepts as part of dialogue and interaction with others, students more actively engaged with the LMS. In more traditional constructivist and assessment-based modules, online activity was found to be substantially lower.[55] Conversely, exercises that seemed merely social in nature, with minimal ties to the learning content, such as personal reflections expressed on discussion boards, did not contribute to a better understanding of the topic.[56]

Over-dependence on content and cognition activities decreases learning
In assessing over 400 million minutes of online learning behavior, Rientes and Toentel[57] found that specific learning design approaches have an impact on learning performance. In particular, modules with a heavy reliance on content and cognition seemed to lead to lower completion and pass rates. Often this reliance includes providing additional material to students in the form of reading lists or additional handouts, with little direction or guidance on how to consume this information, and disrupts the contiguity of the learner's experience.[58]

Learners Benefit From Systems That Support Teacher Designed Curriculum

A system having tools that allow teachers to participate in organizing, interpreting, and localizing existing content, as well as creating appropriate, standards-aligned curriculum, is a critical element in addressing curricular needs and gaps.[59] In terms of using innovative digital curriculum and learning resources in ways that make them more accessible to the learner, similar lines of research focus on the teacher as the primary instrument in creating that access.

> What have often been documented as teachers' adaptations of innovations may have been teachers' innovations created in response to the contexts in which they work. We suggest that part of what teachers learn as they teach is to synthesize new ideas from instructional models they imitate. That is,

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[54] "Social Constructivism: A Variety of Cognitive Constructivism That Emphasizes the Collaborative Nature of Much Learning." 2014. Social Constructivism | GSI Teaching & Resource Center. Accessed October 14, 2016. <http://gsi.berkeley.edu/gsi-guide-contents/learning-theory-research/social-constructivism/>

[55] Honebein, Peter C., and Thomas M. Duffy and Barry J. Fishman. 1993. "Constructivism and the Design of Learning Environments: Context and Authentic Activities for Learning." *Designing Environments for Constructive Learning* 87-108.

[56] Raspopovic, M. 2016. "Challenges of Transitioning to an e-Learning System." <http://www.irrodl.org/index.php/irrodl/article/download/2172/3610>

[57] "Assimilative Activities." 2016. ResearchGate. Accessed June 2, 2016. <https://www.researchgate.net/publication/296625925_The_impact_of_learning_design_on_student_behaviour_satisfaction_and_performance_A_cross-institutional_comparison_across_151_modules>

[58] "Students, Computers and Learning: Making the Connection." 2015. Accessed June 2, 2016. <http://www.oecd-ilibrary.org/students-computers-and-learning_5jrxqsqd92tc.pdf>

[59] Squire, K. D., et al. 2003. "Designed Curriculum and Local Culture: Acknowledging the Primacy of Classroom Culture." *Sci. Ed.*

teachers infer new knowledge and invent new practices based on instructional models introduced by researchers and others. Classroom innovations are thus co-constructed and socially derived.[60]

Pedagogy Review: Summary

In terms of pedagogy, strategies to increase student engagement range from providing students opportunities to reflect on new information and compare to existing knowledge to allowing students to communicate and collaborate on work in common. Activities that balance social interaction with content examination through the lens of well-developed questions lead to learner persistence and deeper engagement with the content. And finally, learning activities designed, developed, or shaped by a teacher who knows and works with the student directly tend to address the learner's needs and result in higher learning gains.

[60] Randi, Judi, and Lyn Corno. 1997. "Teachers as Innovators." *International Handbook of Teachers and Teaching* 1163-1221.

Platform Findings Review

Refers to the architecture, user experience and interface design, and tools used to navigate, search, store, annotate, author, collaborate, communicate, and share.

Supporting Learner Inquiry and Learning Persistence

When reviewing digital or analog content, students benefit by having consistent access to the guiding questions and instructional scaffolding that frames their inquiry. Ideally, just as teachers need to have clarity on the intended learning and indicators of progress, so do the students.[61] Therefore, beyond the assembly and distribution of resources and content, effective digital learning environments should make it possible to take notes, annotate, and reflect on their work. This system-enabled assistance can act as a means of fostering self-regulated learning.[62]

To aid with motivation and persistence, students need methods by which to document and reflect on their learning as it occurs both simultaneously and across time.[63] This type of documentation provides students the means to access and reflect on prior knowledge and then readily build upon it with new information as they progress. Students have to remember what they have done on previous days, including things like the terms they have searched and the websites they have browsed.

"Transactional distance" is the term used to describe the steps a learner must take to move from the learning content to the activities that require referencing of that content. It is difficult for learners to keep track of their work as they transition from content to tool.[64] Also, studies have shown that when systems do not provide clear paths for students to navigate from deliberately structured learning content to the tools to capture and document their learning, navigation missteps become a large contributor to drops in comprehension and eventual learning performance.[65]

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[61] Hattie, John, and Gregory C. R. Yates. 2013. *Visible Learning and the Science of How We Learn*. New York: Routledge.
[62] Winters, Fielding I., and Jeffrey A. Greene and Claudine M. Costich. 2008. "Self-Regulation of Learning Within Computer-Based Learning Environments: A Critical Analysis." *Educational Psychology Review* 20.4: 429-444.
[63] Wolters, Christopher A., and Paul R. Pintrich. 1998. "Contextual Differences in Student Motivation and Self-Regulated Learning in Mathematics, English, and Social Studies Classrooms." *Instructional Science* 26.1-2: 27-47.
[64] Zhang, Meilan, and Chris Quintana. 2012. "Scaffolding Strategies for Supporting Middle School Students' Online Inquiry Processes." *Computers & Education* 58.1: 181-196.
[65] "Students, Computers and Learning: Making the Connection." 2015. Accessed June 21, 2016. <http://www.oecd-ilibrary.org/students-computers-and-learning_5jrxqsqd92tc.pdf>

User Communication and Collaboration

The use of computer and digital technologies is usually more productive when it supports student collaboration and interaction, particularly collaborative use for formal learning when teachers use it to support discussion, interaction and feedback.[66] In contrast to students' experiences in formal learning environments that benefit from teacher-led assessment, online learning communities can generate informal peer-based feedback environments. Within online learning communities used by young people, the degree to which communication is regarded as authoritative and valued is more dependent upon peer recognition, where participants gain status and reputation for their ongoing contributions but do not necessarily hold evaluative authority over one another.[67] Social interaction, demonstration of learning achievements, and engaging larger audiences instill foundational motivations to participate. In terms of evaluative communication directly focused on their progress, students engaged in the online learning environment, as an adjunct to these less formal dynamics mentioned, still benefit immensely from communication generated by their instructor or teacher on their progress.[68]

Effective Website Characteristics Supporting Exploration and Efficacy

The specific challenges described by Ito et al. pertain to the value of the socialization efforts and processes that work to help learners identify and espouse their own learning intentions or interests as a means to forge effective learning environments and communities.

> Rather than seeing socializing and play as hostile to learning, educational programs could be positioned to step in and support moments when youth are motivated to move from friendship-driven to more interest-driven forms of new media use. This requires a cultural shift and a certain openness to experimentation and social exploration that is generally not characteristic of educational institutions, though there are many instances of media production programs and parents supporting these activities.[69]

Findings show that certain website characteristics play a role in allowing users to experience what Chung refers to as "perceived playfulness." The elements contributing to this characteristic are contemporary content, speed of site, ease of use, navigation that facilitate a learner wandering and experimenting with a variety of media and resources, and feedback when participating in activities. These elements help support students' acceptance of the online environment. Students respond positively to an environment that can be navigated in

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[66] Higgins, S. 2012. "The Impact of Digital Technology on Learning." <https://v1.educationendowmentfoundation.org.uk/uploads/pdf/The_Impact_of_Digital_Technologies_on_Learning_FULL_REPORT_(2012).pdf>

[67] Ito, M. 2008. "Living and Learning with New Media - Digital Youth Research." <http://digitalyouth.ischool.berkeley.edu/files/report/digitalyouth-WhitePaper.pdf>

[68] Marks, Ronald B., and Stanley D. Sibley and J. B. Arbaugh. 2005. "A Structural Equation Model of Predictors for Effective Online Learning." *Journal of Management Education* 29.4: 531-563.

[69] Ito, M. "Living and Learning with New Media - Digital Youth Research." 2008. <http://digitalyouth.ischool.berkeley.edu/files/report/digitalyouth-WhitePaper.pdf>

linear and nonlinear ways, and allows peers to visually monitor their progress and share their experiences.[70]

Based on Wang's suggestions for improving user satisfaction in online contexts, learning systems should provide up-to-date content that can fit users' needs.[71] In addition, learning systems should enable users to choose what they want to learn, control their learning progress, and record their learning performance through visual indicators of progress. Three critical findings were:

- Perceived playfulness and self-managed learning skills such as time-management, goal setting, and development of extended questions have more influence on a student's acceptance of a new digital learning resource than previously thought.

- Those students who expect a system to perform well and also find that system to support open, self-led exploration and experimentation are more inclined to use digital learning resources regularly and effectively.

- Students, unlike older users, do not assume that a new digital resource or learning site will require a large amount of effort to use, nor are they necessarily influenced significantly by opinions (good or bad) of those with identified authority or expertise about a given resource or site.

Platform Review: Summary

Characteristics of sites that effectively engage and support learning are ease of navigation, presentation of contemporary content suited to learning needs, inclusion of means to record and visualize progress, and promotion of individual or personalized exploration and discovery. When systems are successful at providing a flexible, collaborative, intuitive experience, and allow students to engage in their own discovery, development, and sharing, they are apt to engage in meaningful use regardless of the perceived learning effort or social influence of those promoting the site.[72]

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[70] Chung, Janine, and Felix B. Tan. 2004. "Antecedents of Perceived Playfulness: An Exploratory Study on User Acceptance of General Information-Searching Websites." *Information & Management* 41.7: 869-881.

[71] Wang, Yi-Shun, and Ming-Cheng Wu and Hsiu-Yuan Wang. 2009. "Investigating the Determinants and Age and Gender Differences in the Acceptance of Mobile Learning." *British Journal of Educational Technology* 40.1: 92-118.

[72] Beetham, Helen, and Rhona Sharpe. 2013. *Rethinking Pedagogy for a Digital Age: Designing for 21st Century Learning*. New York: Routledge.

Key Findings

In summary, findings supported by multiple pieces of literature and case studies focus on expanding ways for learners to document their own thinking to support metacognitive processing, monitor their progress while achieving tasks and assignments, and engage in communication as a way to receive feedback and share their work approach. In reviewing these general trends, the following represent a summary of key findings and strategies that have substantial research support.

- Learning flow is more consistent and more readily supports achievement when there is a high level of correlation or alignment between content, objects/resources, visual supports or media, and tasks to aid in persistence and minimize cognitive load.[73,74]
- Developing and sustaining an online learning community focused on inquiry and learning is crucial in helping students access both their instructors and peers.[75] Sharing their thinking, their findings, and their learning processes, and having access to those of their peers, helps validate work approach, keeps students engaged, and provides an opportunity to blend social, cognitive, and teaching dynamics.[76]
- Students' engagement and performance levels increase when quality content and activities are developed by a learner's own teacher.[77]
- Mutual problem-solving or co-development of learning products helps young students make more meaningful connections to their learning and to one another through establishing relationships focused on learning outcomes.[78]
- Presenting students with open-ended, deep, interesting questions and keeping those questions central and accessible to students throughout their inquiry process[79] helps guide targeted inquiry and progress through complex tasks online.[80]

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[73] Mayer, Richard E, and Richard B. Anderson. 1992. "The Instructive Animation: Helping Students Build Connections Between Words and Pictures in Multimedia Learning." *Journal of Educational Psychology* 84.4: 444.
[74] Moreno, Roxana, and Richard E. Mayer. 1999. "Cognitive Principles of Multimedia Learning: The Role of Modality and Contiguity." *Journal of Educational Psychology* 91.2: 358.
[75] Ito, M. "Living and Learning with New Media - Digital Youth Research." 2008. <http://digitalyouth.ischool.berkeley.edu/files/report/digitalyouth-WhitePaper.pdf>
[76] Higgins, S. 2012. "The Impact of Digital Technology on Learning." <https://v1.educationendowmentfoundation.org.uk/uploads/pdf/The_Impact_of_Digital_Technologies_on_Learning_FULL_REPORT_(2012).pdf>
[77] Squire, K. D., et al. 2003. "Designed Curriculum and Local Culture: Acknowledging the Primacy of Classroom Culture." *Sci. Ed.*
[78] Marks, Ronald B., and Stanley D. Sibley and J. B. Arbaugh. 2005. "A Structural Equation Model of Predictors for Effective Online Learning." *Journal of Management Education* 29.4: 531-563.
[79] Kapa, Esther. 2007. "Transfer from Structured to Open-Ended Problem Solving in a Computerized Metacognitive Environment." *Learning and Instruction* 17.6: 688-707.
[80] Welch, Wayne W., et al. 1981. "The Role of Inquiry in Science Education: Analysis and Recommendations." *Science Education* 65.1: 33-50.

- Having timely feedback on performance,[81] from an instructor or even just in the form of external validation of task completion, serves as a key motivator and aids student persistence.[82]
- Students bring specific expectations to digitally-supported learning environments, including a desire to personally define how accessing and organizing resources and information works for them, flexibility in qualifying the expertise of their instructor and peers, and the freedom to create unique demonstrations of knowledge.[83]
- In the area of personal inquiry and progress monitoring,[84] visual indicators that document and share a learner's progress towards completing online tasks can help young students keep on track and stay motivated as a means of documenting and showcasing achievement.

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[81] Winters, Fielding I., and Jeffrey A. Greene and Claudine M. Costich. 2008. "Self-Regulation of Learning Within Computer-Based Learning Environments: A Critical Analysis." *Educational Psychology Review* 20.4: 429-444.
[82] Wolters, Christopher A., and Paul R. Pintrich. 1998. "Contextual Differences in Student Motivation and Self-Regulated Learning in Mathematics, English, and Social Studies Classrooms." *Instructional Science* 26.1-2: 27-47.
[83] Chung, Janine, and Felix B. Tan. 2004. "Antecedents of Perceived Playfulness: An Exploratory Study on User Acceptance of General Information-Searching Websites." *Information & Management* 41.7: 869-881.
[84] Hattie, John, and Gregory C. R. Yates. 2013. *Visible Learning and the Science of How We Learn*. New York: Routledge.

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