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Abstract

New learning environment designs and frameworks have emerged that are consistent with constructivist-inspired views of learning. Collectively, student-centered, open learning environments provide contexts wherein the individual determines learning goals, learning means, or both the learning goals and means. The individual may also establish and pursue individual learning goals with few or no external boundaries as typical during spontaneous, self-initiated learning from the Web. The approaches represent fundamentally different learning and design paradigms and philosophies. However, student or self-directed learning has been criticized for lacking compelling evidence to document effectiveness. As new models emerge and technologies develop, we need to both document evidence that supports and challenges student-centered approaches and refine our approaches to designing effective environments. This chapter provides an overview and critical analysis of student-centered learning, and proposes directions for advancing needed research, theory, and practice.

Keywords (separated by "-")	Student-centered learning - Self-directed learning - Problem-based learning - Open learning environments

Student-Centered, Open Learning Environments: Research, Theory, and Practice

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Abstract

New learning environment designs and frameworks have emerged that are consistent with constructivist-inspired views of learning. Collectively, student-centered, open learning environments provide contexts wherein the individual determines learning goals, learning means, or both the learning goals and means. The individual may also establish and pursue individual learning goals with few or no external boundaries as typical during spontaneous, self-initiated learning from the Web. The approaches represent fundamentally different learning and design paradigms and philosophies. However, student or self-directed learning has been criticized for lacking compelling evidence to document effectiveness. As new models emerge and technologies develop, we need to both document evidence that supports and challenges student-centered approaches and refine our approaches to designing effective environments. This chapter provides an overview and critical analysis of student-centered learning, and proposes directions for advancing needed research, theory, and practice.

Keywords

Student-centered learning • Self-directed learning • Problem-based learning • Open learning environments

Introduction

Numerous frameworks, consistent with constructivist epistemology for the design of student-centered learning, have evolved that represent alternative learning and design paradigms and philosophies. Myriad student-centered approaches reflecting epistemological variants have emerged including anchored instruction (Cognition and Technology Group at Vanderbilt, 1992), problem-based learning (Hmelo-Silver, 2004), cognitive apprenticeships (Collins, 2006), computer-supported collaborative learning (Stahl, Kosch-mann, & Suthers, 2006), learning-by-design (Kolodner, 2006), project-based learning (Tal, Krajcik, & Blumenfeld, 2006), and games and simulations (Clark, Nelson, Sengupta, & D'Angelo, 2009). Though operationalized differently, these environments share basic foundations and assumptions regarding the centrality of the individual student in assigning the meaning and relevance of learning.

Similarly in student-centered learning environments, the individual determines the learning goal, the means to support learning, or both (Hannafin, in press). This chapter focuses on student-centered, open learning environments (SCOLEs) in which students negotiate learning via unfettered and largely unstructured or ill-structured Web resources to

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addressed individual learning needs (Hannafin, Hannafin, & Gabbitas, 2009). As these approaches expand and new technologies emerge, disciplined methods are needed to integrate digital resources, tools, and connectivity to support open, student-centered learning. Research is needed to examine the evidence and viability related to underlying theories and assumptions associated with such learning.

In this chapter, we focus primarily on student-centered, open learning environments where students assume responsibility for both identifying and monitoring individual learning goals and selecting and utilizing means to support their learning. We provide an overview of the evolution of SCOLEs, describe a series of examples of these principles in practice, critically analyze evidence for and against SCOLEs, and propose strategies and directions for advancing needed research, theory, and practice.

Evolution of Open Learning Environments

In the early 1990s, work in open learning environments was triggered by studies examining learning in the absence of formal instruction. Open learning environments have been described using terms like informal learning, self-choice learning, spontaneous learning, resource-based learning, and self-directed learning. Building upon different assumptions, as well as associated theory and research, the foundations and assumptions of student-centered learning provided "… interactive, complementary activities that enable individuals to address unique learning interests and needs, study multiple levels of complexity, and deepen understanding" (Hannafin & Land, 1997, p. 168).

Hill and Hannafin (2001) adapted this perspective for Resource-Based Learning Environments (RBLEs): "RBLEs support the individual's effort to locate, analyze, interpret and otherwise adapt information to meet particular learning needs" (p. 42). RBLEs open learning components were classified as comprising enabling contexts, resources, tools, and scaffolds. Resources (static and fixed, and dynamic and variable) provide core information assets available to support learning. Contexts, ranging from externally directed, to individually generated, to negotiated between the individual and external agents, establish the situational conditions within which learning is mediated. Tools (searching, processing, manipulating, communicating) "enable learners to organize and present their understanding in concrete ways" (p. 43). RBLE scaffolds (metacognitive, procedural, conceptual) support individuals as they identify relevant goals, pursue and monitor efforts toward those goals, and reconcile differences in their understanding (see also, Hmelo-Silver, Duncan, & Chinn, 2007). RBLE structures and principles were subsequently extended to informal learning and negotiated learning environments (Hill, Domizi, Kim, Kim, & Hannafin, 2007).

To identify commonalities and distinctions among learning environments, both similarities between and distinctions among the foundations, methods, and models associated with direct and open learning environments were presented (Hannafin, Land, & Oliver, 1999). While different approaches build upon foundation research and theory, the underlying epistemologies and associated assumptions separating directed and open learning approaches varied substantially. Given different learning goals and adherence to assumptions as to the nature of learning and understanding, a learning environment design necessarily reflects underlying differences. This became the core premise of grounded design practice for open learning environments (Hannafin, Hannafin, Land, & Oliver, 1997; Hannafin, Hill, & Glazer, 2011; Kim & Hannafin, 2008).

Student-Centered, Open Learning Environments

SCOLE frameworks emerged within and have since been refined by learning scientists and learning systems designers. SCOLEs facilitate student- or self-directed learning by guiding and supporting students as they engage complex, often ill-structured, open-ended problems. The approaches are designed to support individual student sense-making using technology tools, resources, and scaffolding (Quintana, Shin, Norris, & Soloway, 2006). SCOLEs provide contexts wherein the individual determines the learning goal, learning means, or both the learning goals and means (Hannafin, in press). An individual may establish and pursue specific individual learning goals with few or no external boundaries as typical during spontaneous, self-initiated informal learning. Alternatively, the individual may have access only to specific, defined resources to pursue individual learning goals during free-time learning in formal settings; where learning goals are externally established as in most formal school settings, the individual determines how they will be pursued. In essence, the cognitive demands shift from externally mediated selecting, processing, and encoding during directed learning to individually anticipating, seeking, and assessing relevance based on unique needs and goals (Hannafin, Hannafin, et al., 2009; Hannafin, Hill, Oliver, Glazer, & Sharma, 2003; Hannafin, West, & Shepherd, 2009).

SCOLEs emphasize the individual's capacity to identify relevant resources and mediate cognitive demands (Hannafin et al., 1997). Since neither goals nor means are explicitly specified a priori, scaffolding often assumes the form of self-checking, navigation guidance, reassessing and evaluating progress, reexamining goals and progress, reflecting on state of understanding, and resetting and refining goals or strategies. SCOLE scaffolds may help to identify initial understanding in order to build from and refine, rather than to impose canonically correct or generally accepted views on, existing beliefs and dispositions (Kim, Hannafin, & Bryan, 2007).

SCOLE Assumptions

SCOLEs share important assumptions of situated learning theory (Barab & Duffy, 2000) which suggests "… a reformulation of learning in which practice is not conceived of as independent of learning and in which meaning is not conceived of as separate from the practices and contexts in which it was negotiated" (p. 26). Barab and Duffy noted that communities of practice (COPs) comprise "a collection of individuals sharing mutually defined practices, beliefs, and understandings over an extended time frame in the pursuit of a shared enterprise" (p. 36). Understandings develop through participation in authentic contexts (practices, situations, and processes) that shape how knowledge acquires meaning and is applied in context.

SCOLEs emphasize the (a) centrality of the learner in defining meaning; (b) scaffolded participation in authentic, often ill-structured tasks, and sociocultural practices; and (c) access to diverse perspectives, resources, and representations; and (d) importance of learner prior experiences in meaning construction. SCOLEs support the individual's efforts to construct personal meaning. External learning goals may well be established, but the learner determines how, when, and if to proceed based on emergent understanding.

Understanding multiple perspectives is assumed to be critical to deeper, divergent, and more flexible thinking processes. SCOLE advocates assume that individual understanding is deepened by providing varied rather than singular perspectives, resources, and representations. Such approaches may employ teacher–student or student–student interactions to model reflection and performance (see for example, Palincsar & Brown, 1984). Shared understandings across teachers, experts, and peers may be represented as community knowledge from which learners evaluate and negotiate varied sources of meaning (Scardamalia & Bereiter, 2006).

Multiple representations are assumed to be supported through tools that aid in visualizing and manipulating "hard-to-see" concepts, enabling learners to consider ideas and perspectives otherwise inaccessible to them. Simulations, GPS data and maps, and virtual worlds allow learners to visualize and experience complex representations of concepts, thus adding to the richness of perspectives available on the topic. These externalized representations enable new forms of discourse and engagement (Roth, 1995), thus enhancing, augmenting, or extending thinking or perspectives (Pea, 1985).

Individual prior knowledge and experience play critical roles for all learning, but present unique challenges for SCOLEs. Prior knowledge and experience are assumed to form the conceptual referent from which new knowledge is organized and assimilated, as learners' prior knowledge and beliefs influence what they perceive, organize, and interpret (Bransford, Brown, & Cocking, 2000). Understanding dynamically evolves as ideas are generated, expanded, tested, and revised (Land & Hannafin, 1996); learners may evolve durable but naïve and incomplete beliefs and models rooted in their everyday experience. While personal models can be tacit and at odds with accepted notions, they form the basis through which learners interpret and explain new concepts. Interpretations and explanations may persist in the face of contradictory evidence (Strike & Posner, 1992), suggesting that individual beliefs, understandings, and misunderstandings are not readily modified by simply providing authoritative information or confronting with competing evidence. Because novice learners often lack important background and strategic knowledge for managing their learning processes, they can become overwhelmed by options available and encounter difficulty directing their investigations and make effective decisions (Quintana et al., 2004). Managing the demands of an open-ended task requires tracking findings, deciding what to pursue next, determining how available tools and resources are useful in a problem, and reflecting on what is being learned.

Initial understandings, including canonically accepted conventions as well as misconceptions, are also assumed to influence the ability to detect, interpret, and synthesize knowledge (Bransford et al., 2000). Canonical understandings do not supplant initial conceptions but rather serve to challenge and extend initial assumptions (Jonassen, 1991). Thus, prior knowledge and experience influence the individual's ability to mediate their own learning—a central assumption of student-centered learning.

In order to build upon student understanding, SCOLE contexts emphasize connections with everyday experiences. Understanding and sense-making, uniquely shaped by the individual's prior knowledge and experience, influence both what and how something is known. When learning is anchored in everyday contexts, learners are more likely to understand how concepts are applied and why they are useful, facilitating transfer (Bransford et al., 2000). Making connections to everyday contexts guides students to enrich and integrate schooling and life experiences and to develop meaningful, long-lasting interests and understandings (Bell, Lewenstein, Shouse, & Feder, 2009).

To facilitate understanding and meaning-making, SCOLEs assume that authentic experiences or realistic simulations serve to stimulate engagement and interaction (Bransford et al., 2000; Collins, 2006; Edelson & Reiser, 2006). These contexts help students to identify learning goals, formulate and test predictions, and situate understanding within the individual student's experiences while enabling them to understand ordinary practices from a real-world perspective.

Given the importance on decision-making, self-monitoring, and attention-checking skills, learners are provided opportunities to make choices and pursue individual interests. This is assumed to afford opportunities to cultivate deeper understanding of and responsibility for learning. Rather than compliant understanding based on external expectations (McCaslin & Good, 1992), learners are assumed to hone personal strategies, plan and pursue goals, integrate new knowledge with existing, formulate questions and inferences, and refine and reorganize their thinking (Bransford et al., 2000).

SCOLEs also assume that knowledge understanding and application are enhanced when practical utility is apparent and relevance for interpreting, analyzing, and solving real-world problems are apparent. While all learning is considered to be contextually based, SCOLEs assume that rich learning contexts support the meaningful activation of personal knowledge and experience. Solving classical textbook mathematical equations independently of authentic contexts may promote isolated, naive, and oversimplified understanding (Brown, Collins, & Duguid, 1989). The knowledge, however, may be of limited utility and applied mainly to near-transfer problems (e.g., other textbook problems) where the algorithm can be equivalently matched but fail to flexibly apply or support critically reasoning for far-transfer or novel tasks (Perkins & Simmons, 1988).

Finally, while the role of the individual in both uniquely defining and monitoring understanding is assumed to be essential to promote autonomy and ownership of the learning process, these processes may not occur spontaneously without support. To support the individual's learning, therefore, SCOLEs scaffold thinking and actions to facilitate ongoing management and refinement of understanding. These cognitive and metacognitive demands are often supported through structures and guidance embedded within the environment.

SCOLE Examples

Land, Hannafin, and Oliver (in press) detailed diverse student-centered environments across domains which feature the primacy of students in selecting and mediating individual learning. The Web-Inquiry Science Environment (WISE), for example, scaffolds middle-grades science learning (Linn, 2006; Linn, Clark, & Slotta, 2003). Students interact in a virtual laboratory to inquire, experiment, and compare predictions about everyday scientific phenomena in their environment. Students are supported as they conduct investigations, use simulation tools to develop, test, and refine explanations of their findings, and compare and contrast their assumptions and conclusions to integrated WISE problems (e.g., how far does light travel?). Individuals initiate inquiries to understand, interpret, and build upon what they know.

In Stickler and Hampel's (2010) collaborative language learning environment (*Cyber Deutsch*), students interact using assorted tools and practice language via authentic communicative practices. They videoconference and participate in asynchronous discussion forums and question each other as they practice their language skills by blogging and contributing to wikis.

The *Jasper Woodbury Series* (Young, 1993) presented a variety of open-ended dilemmas that anchored mathematics in rich, video vignettes. Using the *anchored instruction* framework (CTGV, 1992), video vignettes present stories about everyday problems faced by the story's lead character, Jasper. The information needed to solve the problem is embedded within the story itself rather than presented and practiced in isolation. One Jasper dilemma involves determining whether or not sufficient time is available to drive a newly purchased boat home before sunset. Information relevant (as well as irrelevant) to solving the dilemma is embedded naturally within the story, and students must identify and generate potential problems and sub-problems. For instance, mile markers, periodic fuel readings, amount of fuel purchased, and time of day are embedded naturally within the story. Once the macro-context is introduced, students identify relevant information prior to generating potential sub-problems to the multifaceted and complex dilemma.

The *Jasper* series and anchored instruction frameworks have been successfully applied to encompass varied problem sets and contexts. The *Blueprint for Success* episode, for example, requires learners to apply geometry concepts to design a virtual playground. Another problem asks learners to consider whether Jasper will be able to transport a wounded eagle to safety using his ultralight airplane, while a different problem asks learners to design a school fair and to design and fill a dunking booth for teachers. *Jasper* also addresses transfer issues through a series of analog and extension problems. By presenting pairs of related adventures (e.g., trip planning) students are scaffolded in analyzing which concepts are generalizable across contexts and which are specific to the given context.

Learning communities, sometimes tacitly and often explicitly, manifest SCOLE foundations, assumptions and features. Within learning communities, "there is a culture of learning in which everyone is involved in a collective effort of understanding" (Bielaczyc & Collins, 1999, p. 271). The *Knowledge Forum*, for example, emphasizes collectively building and improving upon emergent understanding. Technology tools are used to post ideas and notes as well as to comment on and organize individual and shared understandings (Scardamalia & Bereiter, 2006). Students act as agents of their own understanding while generating and contributing both individual and collective knowledge. Recently, technology tools have also been employed to support informal learning communities of practice (COPs). Company

Command (Hoadley & Kilner, 2005), an online COP for US Army officers, brings together remotely distributed military commanders to support each other's leadership practice. Similar COPs have been employed to support communities as diverse as novice and beginning practicing teachers (Barab, Barnett, & Squire, 2002) and distributed automobile sales and service personnel in improving practices (Land et al., 2009).

SCOLE games and simulations have also seen widespread growth in interest and use. *Civilization III*, a hybrid game/simulation, has been used in education contexts to cultivate learning related to historic events and nation building. Using program rules (e.g., food needed to sustain a given population; land needed to produce required housing and food), authentic scenarios induce students to initiate or defend against war or compete with other civilizations online. Charsky and Ressler (2011), for example, scaffolded ninth graders' emergent conceptual understanding of global history, but noted that in-game support seemingly compromised the autonomous of gaming activities.

In *Crystal Island*, students engage scientific decision-making at a virtual research station to examine why scientists became ill. The simulation embedded conceptual and metacognitive scaffolds within character dialogues, and procedural scaffolds in the form of virtual lab tools for testing hypotheses. The scaffolding strategy adapted support based on ongoing student understanding and decision-making. For example, if students failed to apply a reasonable, systematic approach to address the problem, the simulation initiated strategic scaffolds requiring students to reconsider key components before proceeding. Students who successfully applied their knowledge were able to rule out unlikely hypotheses and generate appropriate hypotheses (Spires, Rowe, Mott, & Lester, in press).

Plantation Letters is a collection of nineteenth century letters written to and from American plantation owners. The letters are used to support inquiry across a range of questions, topics, and issues. Students access the letters using health-related tags to study conditions contributing to medical problems among the enslaved population (Oliver & Lee, 2011). Multiple perspectives on medical crises can then be referenced by reading across cases involving chronic health problems as well as by accessing recent medical crises brought about by natural disasters. Students share their approaches and develop a consensus to address the health crises via a social network. In a different lesson, scaffolds guide students in historical inquiry to pursue themes of personal interest. Students index information about their selected source, note contextual information within the source, draw inferences regarding broader historical questions, and monitor their assumptions and interpretation. Teachers can also utilize Web-based tools to support this work. *The History Engine* provides opportunities to publish interpretations of primary historical sources and engage historical experts and students during analysis (Benson, Chambliss, Martinez, Tomasek, & Tuten, 2009).

Klopfer and Squire (2008) embedded augmented reality within a GPS-enabled handheld device in *Environmental Detectives* which presents an open-ended environmental problem where the problem source could not be immediately identified. They "create[ed] an experience where players had to think about the nature of the problem, design data collection strategies, reflect on their data collection in progress, analyze and interpret data, and then revise hypotheses, data collection strategies, and emerging theories of the problem" (p. 216). Their development process included rapid prototyping, learner-centered design, and contemporary game design.

Finally, Lindsay and Davis (2007) examine and compare perspectives on the influence of contemporary trends on world connections. *Flat Classroom* supports students as they traverse individual and class-level inquiry, attempt reconciliation of alternative global perspectives, use technology tools in support of constructivist projects, and enable peer and adult scaffolding. Middle- and high school classrooms worldwide use asynchronous and synchronous communication tools to exchange views and co-construct wiki spaces and video artifacts of their understanding, incorporating resources from partner schools to encourage and facilitate collaboration. Geographically distributed students convene virtual summits where they share work while receiving experts' feedback.

Reexamining SCOLE Research, Theory, and Practice

The perspectives of researchers and theorists often vary dramatically with respect to the importance of underlying assumptions and associated strategies. In this section, we contrast perspectives opposed to and in support of SCOLEs.

The Case Against

To scholars who emphasize externally defined learning outcomes, SCOLE principles and practices lack empirical foundation and are applied in misguided ways (see, for example, Clark & Feldon, 2005). These criticisms are bolstered by research indicating the need for and effectiveness of direct instruction over general advice (Kester & Kirschner, 2009; Kirschner, Sweller, & Clark, 2006; Sweller, Kirschner, & Clark, 2007) and the consequences of stimulus overload in loosely- or ill-structured learning environments (Mayer, Heiser, & Lonn, 2001). R. Clark recently described "pitfalls" and shortcomings of constructivist-inspired learning environments such as discovery learning research and practice, citing examples to support his assertion that fully guided, direct instruction results in superior performance in virtually all cases (Clark & Hannafin, 2011). Similar arguments have been presented for constructivist-inspired learning strategies and environments including student-centered learning, inquiry-based learning, and self-directed learning (Kirschner et al., 2006).

Clark also suggested that empirical evidence generated from directed-learning studies is applicable to all types of learning independent of the associated epistemological roots. He suggests personal perspectives might unduly sustain the popularity of minimally guided approaches in the absence of empirical evidence. He cautioned: "Far too many in our field are avoiding inconvenient evidence in favor of self-serving beliefs and opinions" (Clark & Hannafin, p. 375). He further questioned the preparation and motivation of nonadherents: "few people have the motivation or training necessary to invest the effort required to carefully review complex research on learning and instruction…ambivalence about research training in our instructional technology and instructional systems graduate programs is certainly a contributing factor" (p. 375). Clark concluded that programs that do not heed his advice "risk causing harm to people who depend on us" (p. 375).

These perspectives are not isolated, and similar opinions have been advanced by leading figures in the instructional design field. Merrill, Drake, Lacy, Pratt, and ID2 Research Group (1996), for example, stated that the instructional design field had misguidedly strayed from its empirical research and theory roots and become enamored with unproven fads and trends and abandoned the discipline and scientificism of learning researchers. They argued strenuously to reclaim instructional design from those who have shifted away from the science of instruction and the technology of design. Merrill and ID2 colleagues characterized the trend as being fomented by wild speculation and extreme, unscientific philosophy. Similarly, Walter Dick (1991) questioned the applicability and appropriateness of constructivism, perhaps the most commonly ascribed epistemological basis for SCOLEs, as a viable frame for designing instruction and evaluating student performance.

These criticisms have been well-documented in the instruction and instructional design fields, though significant developments have become apparent both within and beyond the instructional design field. While gaining considerable momentum and traction, disagreements have emerged in the past and continue to emerge at the present time.

The Case For

Although critics' arguments have face validity, their conclusions have been based largely on externally mediated learning: All learning is not mediated by engineered instruction. Instead, individuals learn and interact continually and dynamically, negotiating meaning and understanding and learning within their everyday environments. This is evident in how and why we access the Web to identify a wide range of everyday resources, including to locate resources for formal school lessons and projects, plan travel, identify activities of interest for children, plan for retirement, shop comparatively online, and a virtually unlimited number of planned and spontaneous learning tasks. Instruction comprises one significant option to promote and support learning, and in many cases it may be the best option but clearly not the sole or exclusive approach.

SCOLE proponents suggest that the goals, assumptions, and learning contexts of student-centered learning differ substantially from those of direct instruction. Clark et al.'s perspectives, methods and findings are at odds with widely adopted approaches advanced by other reputable theorists, researchers and practitioners. Kuhn (2007), for example, suggested that instructional methods should be considered in light of the broader context of instructional goals about *what* is important to teach, and that alternatives to direct instruction are warranted. Hmelo-Silver et al. (2007) challenged use of the critics' term minimal guidance: "problem-based learning (PBL) and inquiry learning (IL), are not minimally guided instructional approaches but rather provide extensive scaffolding and guidance to facilitate student learning" (p. 99). Optimal guidance is needed where learning outcomes are not or cannot be explicitly predefined. Further, McCaslin and Good (1992) noted, "the intended modern school curriculum, which is designed to produce self-motivated, active learners, is seriously undermined by classroom management policies that encourage, if not demand, simple obedience" (p. 4). The authors suggest that both teachers and students require sustained opportunities and support in order to adapt and implement significant pedagogical changes.

Hannafin et al. (2009) contrasted time-tested cognitive principles supporting externally mediated learning with student-centered learning, noting "fundamental shifts in cognitive requirements as well as the foundations and assumptions underlying their design and use" (p. 196). The *locus and nature of knowledge*, the *role of context* in learning, and the *role of prior experience* are central to both externally mediated and student-centered approaches, but the associated assumptions and implications vary considerably. Among objectivists, knowledge has been viewed as existing independently of individuals, and is to be acquired and understood according to canonical conventions. Learning contexts comprise stimulus elements and their proximal relationships, and prior knowledge and experience establish and reify strength of association and relationship within complex schemata. In contrast for student-centered learning researchers and theorists, knowledge and meaning do not exist independently from each other but are constructed dynamically by individuals; context and knowledge are inextricably tied and are mutually interdependent, and prior knowledge and experience influence initial beliefs and understanding and must be acknowledged and addressed for learning to become meaningful to the individual.

Unlike the time-tested principles underlying externally mediated instruction, the research and theory base underlying SCOLEs is still emerging. Some have suggested that learning demands become increasingly complex since individual "meaning" is influenced more by the diversity between than the singularity across learners. According to Land (2000, pp. 75–76) without effective support,

> misperceptions, misinterpretations, or ineffective strategy use … can lead to significant misunderstandings that are difficult to detect or repair…metacognitive and prior knowledge are needed to ask good questions and to make sense.

Optimal not absolute guidance is indicated where learning outcomes are not or cannot be explicitly predefined. We need to understand diverse perspectives and assess their potential implications and not either blindly accept or dismiss them. The case against student-centered learning has been advanced; Duffy and Jonassen (1992) presented their case for the emergence of constructivism and its impact on instruction. Tobias and Duffy (2009) compiled chapters authored by well-known proponents as well as critics of different perspectives. Both similarities between and differences among perspectives need to be recognized and understood.

The Future: Where Should We Go from Here?

Although SCOLEs have the potential to deepen learning when strategies are followed, associated strategies are often unutilized, misutilized, or underutilized. For example, few researchers have documented conclusive evidence for effective metacognitive scaffolding during student-centered learning. To be effective, students need key domain knowledge and the ability to regulate cognition as they formulate and modify plans, reevaluate goals, and monitor individual cognitive efforts. Such knowledge and skill is necessary but often insufficient, however, as students fail to invoke and regulate their skills when engaging learning tasks that are too easy or too difficult, where they lack motivation to engage the tasks, or when they perceive a lack of relevance. We highlight several areas of particular concern.

Prior Knowledge and Experience

Prior knowledge and experience are considered critical during SCOLEs, but are often incomplete and inaccurate (Land, 2000). Lacking adequate background, learners fail to detect inaccurate information or reject erroneous hypotheses upon encountering contradictory evidence. Rather than building from and refining initial understanding rooted in personal experience, misconceptions become reified. Without appropriate guidance and support, misinformation may go undetected as beliefs associated with misunderstandings are strengthened rather than reconciled.

Scaffolding

How much support is needed, and appropriate for, the different aspects of student-centered learning? Some have suggested that maximum guidance (scaffolding) is most effective for *all* types of learning, but the basis and rationale for this conclusion have been challenged. Soft scaffolding, provided dynamically and adaptively by teachers, peers and other human resources to accommodate real-time changes in needs and cognitive demands, has proven inconsistent in implementation frequency, quality and impact on student learning. Similarly, technology-enhanced support (hard scaffolding) has proven effective in learning basic information, but often ineffective in promoting the generalizable reasoning and thinking valued in student-centered learning. Clarebout and Elen (2006), for example, were able to scaffold college students' performance during open-ended learning tasks using pedagogical agents, but only with fixed (versus adaptive) advice.

Assuming scaffolding is provided, how should we measure individual student-centered learning and performance? How will we (or will we be able to) assess success or failure of SCOLEs to attain individually generated goals? Any approach should yield superior results when assessments are appropriately aligned: SCOLE students should not perform as well as those receiving direct instruction when assessments are focused solely on externally defined knowledge and skill requirements; predictably, students receiving maximum guidance would not perform as well as on assessments of SCOLE thinking or reasoning. Given increased accountability expectations with unpredictable variations in individual prior knowledge and experience, research is needed to study how scaffolding variation are utilized individually, how meaning is influenced by individual needs and goals, and how individual needs are (and are not) addressed.

Metacognition

Metacognition may be among the most important yet potentially most problematic cognitive constructs associated with SCOLEs. Since student-centered learning emphasizes learning in un-, less-, or ill-structured environments, the ability to monitor one's cognitive processes is fundamental to evaluating progress toward meeting individual learning goals and means. Students who have, or develop, metacognitive strategies tend to perform more successfully than those who do not. Thus, research is needed to clarify the extent to which learners must possess initially, require advance training prior to, or can develop the requisite skills needed to monitor their progress during student-centered learning.

Cognitive Demands

Existing cognitive load research and theory present possible explanations for managing cognitive demands, but given the cognitive demands associated with student-centered learning we need to better understand how, when, and if individuals manage cognitive load. Intrinsic cognitive load reflects the difficulty inherent in the information to be learned, germane cognitive load reflects the effort needed to create relevant schemas and models for future learning, and extraneous cognitive load reflects nonrelevant cognitive requirements associated with the instructional materials, methods, and environment. Ton de Jong (2010) argued that different types of cognitive load are often indistinguishable, variations in instructional format influence both the nature and distribution of cognitive load, individual learner differences are rarely accounted for, and efforts to measure cognitive load often do not provide valid or differentiated estimates. He proposed that cognitive load efforts be directed to measure perceived "difficulty of the subject matter… of interacting with the environment itself…helpfulness of the instructional measures used" (p. 119).

These issues are particularly critical during student-centered learning where distinctions between and among different types of cognitive load are individually differentiated. In SCOLEs, it is not possible to anticipate which resources and activities are extraneous, intrinsic, or germane independent of individual learning goals, background knowledge and experience. Given the ill-structured and highly individualistic nature of student-centered learning, little inherent organization is available to clarify the intrinsic importance, or difficulty of, to-be-learned information. Normally, this support is managed and brokered within structured instruction. Individuals, unable to distinguish important from unimportant information (thereby increasing extraneous load), lack the structures normally provided to support cognitive processing, construction, and schema activation.

Given equivocal findings, many question whether students *can* manage the cognitive demands associated with SCOLEs. Bannert (2002) described potential influences of internally managed cognitive load: "it appears very important to find out … which training format learners would choose if they were able to decide themselves and also to examine if learner-control treatments would also be superior with respect to training efficiency and transfer performance" (pp. 145–146). Since students must assess veracity and relevance while addressing individual learning goals and monitoring understanding, research is needed to examine how cognitive load theory and constructs vary as learners become increasingly facile with, or frustrated by, their individual learning tasks. While cognitive load scholars continue to question the viability of self-regulated learning, Bannert (2002), DeSchryver and Spiro (2009), and de Jong (2010) underscore the significance and potential of further research in student-centered learning.

Methods

What research questions need to be addressed and what types of methods are needed? Are findings from SCOLE-related research fundamentally flawed? According to Clark and colleagues, the methodologies are misguided. No doubt there is insufficient and questionable rigor in many published reports, but the questions posed necessitate methodologies that differ from experimental approaches. Disciplined methods appropriate to student-centered approaches have been advanced and practiced by well-regarded researchers. It is inappropriate to apply methods and standards that are not aligned with or address the questions posed; it is also naive to categorically discount such research simply for not employing experimental methodologies. SCOLE research paradigms place increased emphasis on the study of technological and pedagogical innovations in situ—that is, within authentic classroom contexts. Design research reflects a methodological shift to better address the situated nature of SCOLE research, theory, and practice.

Lingering Questions

How do students perceive student-centered learning? Contradictory findings have been reported related to students' preferred learning style (Kumar & Kogut, 2006). While some allege that students are most comfortable with traditional didactic approaches, others report that students prefer to be active and engaged in their learning process (Dochy, Segers, van den Bossche, & Struyven, 2005). In either case, significant reliance on self-directed learning will continue whether or not directed teaching options are available.

Similarly, do SCOLEs trigger and sustain students' motivation? Many laud SCOLEs for stimulating intrinsic motivation. Blumenfeld et al. (1991) investigated the influence of student-centered, project-based learning on triggering and sustaining motivation. According to self-determination theory, students who experience autonomy, relatedness, and competence should demonstrate greater volition and motivation to engage activities that enhance performance, persistence, and creativity (Deci & Ryan, 2000). Assuming increased student agency in establishing and pursuing individual learning goals, we might expect such outcomes, but findings from research to date remain equivocal.

Conclusions

Teaching and learning needs are sometimes straightforward (or can appear such), but often they are not. We cannot always anticipate a priori the unique learning needs of each individual in order to judge how much or little they already know, how relevant the knowledge is to the current learning goal, how well-founded their current understanding is, or how, when and where different learning needs will surface. It is not possible to predesign maximum guidance or direct instruction to support infinite differences in prior knowledge, ability, learning goals or the spontaneous circumstances within which they emerge.

To the contrary, the lack of success with and satisfaction for didactic approaches have stimulated theory, research, and development to support higher-order thinking, reasoning, and decision-making. We may well continue to adhere to individual or community biases and beliefs, but it has become clear that significant scholars in the broad community are invested in refining SCOLE theory, research, and practice.

While guidelines have been offered to support SCOLE design, often they lack adequate theoretical or empirical framing. There are commonalities across SCOLE approaches, but no unifying theory exists to guide their design or consensus methodology to validate their findings. Some disagreement seems to reflect basic differences in the underlying epistemology while other disagreements appear rooted in what is considered valid methodology. We need to identify frameworks for analyzing, designing, and evaluating SCOLEs. Given underlying differences, such frameworks may not satisfy skeptics with disparate epistemological beliefs, but they should facilitate clearer specification as to how SCOLE variants do, or not, share common foundations and assumptions.

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