EDUCATION, KNOWLEDGE, AND LEARNING
an overview of theories and research about constructionism and making
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Printing Instructions

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It is the perennial question: should education prepare individuals to enter the workforce, or should it focus on social, academic, cultural, and intellectual development so the learner can become an engaged citizen? Should it focus on subject and content knowledge so learners can pass tests and move ahead academically, or should it focus on the self-realisation of the individual, who learns for the excitement and reward of learning, establishing a pattern of life-long engagement? In the world of the Fourth Industrial Revolution, characterised by automated obsolescence as well as increasingly complex and multivalent social and cultural connections, perhaps both questions require re-evaluation. Maybe it is anachronistic even to view them as oppositional—a false dichotomy that blinds us to overlaps and alliances that could otherwise prove fruitful for new educational constructs.

Much of the current educational system has centred on the preparation of a particular kind of workforce, training people to apply predetermined, precontextualised information through a series of formulas, ‘recipes,’ and standardised procedures. Such training was once considered essential for workers in an industrialised economy. But as that economy shifts and as those roles are increasingly adopted by machines rather than people, examining the existing educational system’s impact in preparing learners has led to a series of recent critiques. Reports by the World Bank Economic Forum (2018),\(^1\) the OECD (2018),\(^2\) and a range of think tanks and international organisations (Carneiro, Crawford, and Goodman 2007,\(^3\) Abadzi 2015)\(^4\)

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have declared that education is ill-equipped to prepare learners for the jobs of the future. These jobs will be characterised by a need to collaborate across disciplines, apply knowledge in novel or unanticipated ways, and maintain flexibility as workers train and retrain across the course of a career. Other authorities have pointed to the ways that technology has disrupted employment, making some jobs redundant even as new jobs emerge, requiring new approaches and fluency with an ever-changing array of tools.

What all these recent reports share is a critique of education’s monolithic focus on content knowledge, relying on one-dimensional assessments that are unable to measure and record the skills many employers now recognize as essential: innovation, creativity, entrepreneurship, and resilience. Education needs to prepare people who can work in teams, demonstrate strong leadership and communication skills, and possess the ability to thrive in diverse cultural and social contexts—so-called ‘21st-century skills.’ These qualities are rarely measured by assessment regimes, a cipher left unrecorded because the existing paradigm of standardised, industrialised education has never developed a ‘language’ to encode them.

Not only have such skills gone undocumented and unaccounted for by existing assessment regimes: many educational systems have also neglected approaches for teaching them or even instilling them indirectly. The pedagogical methods many educational programmes use today primarily serve a standardised, industrial, content-delivery-and-reproduction model, with little or no room for learners to acquire or demonstrate skills beyond content knowledge. This has meant that such systems have increasingly diverged from the needs of both today’s society and the current global economic system.

To reclaim its relevance, how can education be redefined to accommodate a more expansive understanding of essential skills and abilities? Of course, calls for a more holistic and inclusive educational programme that moves away from content mastery toward exploration, application, internalisation, and knowledge construction are not new. These ideas are rooted in what early education researchers such as Dewey\(^5\) (1916,\(^6\) 1933)\(^7\)—followed by Piaget (1964)\(^8\), Papert (1980,\(^9\) 1993)\(^10\) and others—have promoted for more than a century. But after all this time, how can we realise a more humane and inclusive

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educational system in which individuals gain the skills and wisdom they will need to thrive—despite a current system that considers these to be antithetical to the educational needs of an industrial workforce? Perhaps an exploration of the theories that underpin learning, knowledge, and education can point us in the right direction.

**TOWARD A HOLISTIC DEFINITION OF LEARNING**

A more inclusive educational programme will require a more holistic definition of learning. Such a definition must note the transformative processes involved in acquiring skills, abilities, experience, and knowledge, and it should also trace the transformations in identity and application that signal their internalisation. While the acquisition of new information is an important part of the learning process, often leading to changes in behaviour and new perceptions of the world, a narrower, more content-focused definition of learning tends to elide learning’s organic, ongoing nature.

A more holistic definition must therefore emphasise not just the static measurement of what knowledge has been transmitted and absorbed, but also the processes by which knowledge is constructed and internalised. The idea that knowledge acquisition could be considered part of a living process, constantly being created and recreated and deeply connected to identity, also places value on the innate, individual attributes each learner brings to the learning experience. Instead of focusing on knowledge as an immutable element to be consumed and reproduced, this more expansive definition would consider the individual learner as a critical factor and agent in the creation of new knowledge. Since it would see learning as part of an ongoing process of transformation and growth, such a definition would also need to consider the contexts in which learners encounter and manifest their learning as a way of situating and explaining this process.

As individual learners apply and demonstrate the knowledge they have gained through projects and actions, it would trace the impact on the learner’s identity, recognising that learning is less about acquiring information or submitting to another’s ideas or values than it is about finding one’s voice and exchanging ideas with others.11 This broader definition of learning considers the “qualitative change in a person’s way of seeing, experiencing, understanding, [or] conceptualising something in the real world”12 rather than limiting itself to the quantitative change in the amount of information a person has at hand. Such a definition places a value on the experiences and behaviours that result from learning and knowledge acquisition, offering new ways to consider learning as a transformative process.

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For these reasons, our discussion will use a more holistic definition of learning that considers both how knowledge is being created and applied experientially and how it is being shared and internalised. Far from being solely a catalogue of transmitted data, this paper’s definition of learning seeks to embrace the processes, products, and resulting shifts in identity that learners manifest as they grow and develop.

DEFINING CONSTRUCTIONIST LEARNING

‘CONSTRUCTIVISM’ AND ‘CONSTRUCTIONISM’ (including the subfields of ‘social constructivism’ and ‘social constructionism’) are two distinct learning methodologies. Although some teachers and theorists use these terms interchangeably, making a distinction between them and understanding their differences may prove helpful as we consider the design of learning approaches (Young and Collin 2004; Hyde 2015).

Constructivism is a theory of knowledge originated by the Swiss developmental psychologist Jean Piaget (1896–1980). Piaget argued that experience doesn't happen in a vacuum: learners interpret their experiences based on their own prior knowledge as well as on the reported experiences of others. In other words, Piaget believed that children construct their knowledge based on what they know, who they are with, and who they are. Because of this interplay between experience, reflection, and identity as the basis for building knowledge, constructivism argues that learning happens best when it is self-directed. Self-direction occurs when learners feel they can exercise authentic control over the content and purpose of their learning: they make judgements regarding the significance and meaning of learning experiences in a way best suited to them. However, this typically does not happen in isolated study; it is a function of the evaluation of shared and mutually interpreted experiences. Piaget's constructivism provides a framework for understanding children’s patterns of thinking and development at different stages of learning (Ackermann 2010).

In constructionism, created by Seymour Papert (1928–2016) of the Massachusetts Institute of Technology, learning happens when children are engaged in constructing meaningful artefacts or objects. Like constructivism, constructionism shares a view of learning that is about the building of knowledge structures through the internalisation of action over time. However, in constructionism, attention is given to the manner of learning – also referred to as the ‘art of learning’ – and to understanding the relationship

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between the learner and the made object. Papert’s (1928–2016) constructionism builds on Piaget’s constructivist theory. He proposed that learners construct mental models to understand the world around them but must then manifest them in the construction of ‘objects-to-think-with’ to complete the process. Constructionism shares constructivism’s view that learning involves ‘building knowledge structures’ through progressive internalisation of actions, but it adds the idea that this happens in contexts where learners are consciously engaged in constructing a ‘public entity.’ Papert explains how his constructionist theory builds on constructivism thus:

From constructivist theories of psychology we take a view of learning as a reconstruction rather than as a transmission of knowledge. Then we extend the idea of manipulative materials to the idea that learning is most effective when part of an activity the learner experiences [involves] constructing a meaningful product. (1)

According to constructivist theory, individual learners construct new knowledge based upon existing and innate knowledge. In other words, learners do not receive knowledge passively, but interpret what they receive, modifying it to construct new knowledge. Constructionist theorists and practitioners agree that learning is an active process, but they argue that it happens most productively when learners make (not receive) ideas and knowledge through the creation of personally meaningful projects. Constructionism goes beyond a superficial or simplistic idea of learning-by-doing, emphasising the roles of both design and digital technology in facilitating knowledge construction through the creation of actual artefacts.

For Papert and his fellow constructionists, the creation of new knowledge is best served in contexts where learners are consciously involved in the design and production of sharable external artefacts (such as physical projects or products), offering learners opportunities to apply the knowledge they are developing. Kafai (2006) describes the artefacts that learners create as ‘objects-to-think-with,’ where the designed artefacts,
in Papert’s terms, “can become objects in the mind that help to construct, examine, and revise connections between old and new knowledge.” For truly effective learning, constructionists believe learners must make discernible objects in real-world contexts for real audiences, drawing their conclusions through creative experimentation and the feedback that results from sharing what they produce.

This emphasis on learner agency contrasts with the more academically prevalent practice of ‘instructionism,’ where knowledge is seen as a static, non-volatile object to be transmitted and absorbed. In part, this shift in emphasis from information to construction is due to more than thirty years of research demonstrating that learners retain only minimal information from exclusively instructionist methods, and they frequently have trouble transferring the information they do retain to new experiences. This difficulty in retaining and using information highlights one reason many have begun looking to constructionist educational approaches.

Constructionism does not merely impact learners, however. To provide greater opportunities for individual agency, constructionism, like socio-constructivism, proposes that teachers act as facilitators, coaching learners rather than subjecting them to lectures or step-by-step guidance (Rogoff 1994). Instructionist ‘lecturing at’ is replaced in constructionism by teachers who serve and support learners working to understand problems and develop their own solutions. Projects where individuals make connections between different ideas and areas of knowledge provide an ideal environment for such learner-directed learning. This has led to momentum behind several ‘new’ learning movements, such as project- and problem-based learning and ‘maker’ education (all three of which are discussed in detail in the next chapter).

Known as ‘active learning’ for their emphasis on learner creation, these constructionist methodologies oppose the passive reception and repetition of information. Yet they also involve more than just active knowledge construction. Learners working through many constructionist approaches are also expected to reflect about their engagement in learning activities and tasks. Emphasising such metacognitive and higher-order thinking, many forms of constructionism incorporate group work, seeing collaboration as a means

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of driving skills and knowledge development while also offering opportunities to engender further reflection and observational opportunities that can drive metacognition.28

Bonwell and Eison (1991) conclude that active forms of constructionist learning lead to better student attitudes and improvements in students’ thinking and writing.29 A meta-analysis study by Freeman et al., (2014) on the impact of active learning in undergraduate STEM classes shows that average examination scores improved by 6% in active learning sessions. Students in classes with traditional lecturing were 1.5 times more likely to fail than students in classes with active learning. Lecturing and the passive reception it requires of students increased overall failure rates by 55%. Active learning strategies benefited all class sizes, although classes with fewer than 50 students saw the greatest impact.30

Currently, educators are using three main forms of constructionist learning: problem-based learning, project-based learning, and ‘maker’ learning. As the next chapter of this paper will outline, each approach differs from the others and offers specific advantages—and reasons for deployment. In a nutshell, in problem-based learning, teachers present a case or problem that learners must think through. Project-based learning takes this approach to the next level by asking students to enact the solution they have developed.

Boiled down, constructionist learning is characterised by five key emphases

(Re)construction of knowledge: learners construct new understandings based on existing knowledge and actively make projects to test and refine the knowledge (and knowledge models) they’re developing;

Learner agency and self-directed exploration: Learners take a central role in the learning process, discovering new knowledge themselves, with teachers acting as facilitators and guides rather than custodians of content;

Learning through designing and social making: Learners are involved in designing and creating artefacts based on their own perspectives and ideas, getting feedback on their understanding not from external assessments (like exams) but from sharing their projects and artefacts with others;

Reflection and metacognition: Learners use the projects and artefacts they make to reflect on their learning, gaining opportunities to consider their own particular learning approaches and processes as a means of facilitating understanding;

Technological literacy: Learners use technology to achieve specific learning goals rather than experiencing technology as a bolt-on or after-thought.

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30 Freeman, et al. (2014). “Active learning increases student performance in science, engineering, and mathematics.”
producing an artefact or application that reflects their attempt to respond to the case or solve the problem. ‘Maker’ learning augments project-based learning by focusing on the collaborative community and productive learning and making spaces in which learners design, develop, and build their projects.

DEMOCRATISATION AND AGENCY IN LEARNER-CENTRIC EDUCATION

What problem- and project-based and ‘maker’ learning share is their emphasis on the learner’s role in constructing knowledge by uniting new information with prior experience. In these learning approaches, the learner is an active participant, with the instructor serving as a mediator and facilitator of learning—a stark contrast to the teacher-centred pedagogical practices constructed around information delivery. In learner-centred approaches, the instructor’s primary task is to create an environment that is conducive to learner agency. Learners are expected to demonstrate their agency by seeking content and topics of their own interest, with instructors curating an environment that facilitates inquiry, discussion, exploration, and spontaneous learning experiences among learners. Within all forms of constructionist learning, therefore, we see a critical shift from the teacher-as-deliverer to the learner-as-discoverer-and-maker. As active agents in the learning process, learners bring their personal insights, knowledge, and experiences to their learning endeavour. They gain an understanding of their environments’ features and characteristics and grow in understanding primarily by constructing their own conceptualisations and finding their own solutions to problems. In this way, learners develop autonomy and mastery while they are acquiring and constructing knowledge.

The outcome of these essential features of learner-centred education is a ‘democratisation’ of learning that shifts the learning environment from being hierarchical, with the teacher occupying a central and elevated position, to being communal, with the teacher in a more collaborative, egalitarian position. In these methodologies, instead of being the primary arbiter of content, the instructor is simply another member of the learning community, albeit one who possesses the important resources of experience, knowledge, and wisdom. This democratic and collaborative shift is necessary to empower the more active role learners take in shaping their learning. In addition, the shift toward a more democratic approach also increases opportunities for learners to serve as resources for their peers, providing a forum where they can share information in the classroom. By providing a platform for learners to share what they are discovering, learner-centred

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33 Wright (2011). “Student-centered learning in higher education.”
approaches provide rich opportunities for students to discover and explore topics of interest without having to adhere to a rigidly predetermined or delimited course of study. Instead, course content serves as a starting point for stimulating exploration, augmented by the resources and approaches that other learners bring.

By giving learners the opportunity to engage in conversation with teachers and peers who direct and expand their learning, they can practice the skills they need for learning outside formal educational settings, honing their ability to support ‘lifelong learning.’ The dialectical approach, in which learners address their own open-ended questions and those from others, exposes them to critical and metacognitive thinking and offers them opportunities to encounter and respond to contradictions in their conceptualisations of the world. By calling attention to the way learning is shaped through dialogue, these constructionist methods remind learners that they need others to refine and develop their thinking. Eventually, such experiences are designed to provide learners with resources, and agency for complex problem-solving and productive collaboration.

Of course, learner-centric education exists on a continuum; some activities or practices may offer more or less learner control. For example, when learners are first approaching a concept or topic, a more teacher-centric approach might be appropriate, while at a later phase of learning, learners might be better served by having full independence. Regardless, the determining criterion should be to give learners the environment they need for growth. Instead of being assessed against an arbitrary measure of content retention, learners’ success in constructionist approaches should be measured by examining their ability to demonstrate their developing knowledge and skills by creating real-world projects.

ASSESSING LEARNER-CENTRIC APPROACHES

One place to observe the benefits of learner-centric learning is Impact Academy in California. The majority of the Academy’s students have minority backgrounds, with a significant percentage coming from socially disadvantaged families. Classes are structured in a learner-led way, with learners regularly prompted to explore, research, defend, and challenge information. Individuals spend approximately 75% of the school day in hands-on activities. The academy uses standards- and research-based assessments to ensure not only that students learn the content in each of their classes, but also that

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they are able to perform solidly on state exams. Additionally, all students must apply for a post-secondary programme. In terms of post-secondary academic performance, 98% of all graduates from the 2011 and 2012 classes enrolled in a 2- or 4-year programme, while 54% of 2011 graduates and 64% of 2012 graduates enrolled in a 4-year college. For learners from the demographics this school serves, this is a very high percentage—one that exceeds state averages.

Other research on learner-centric approaches confirms their positive impact on a more inclusive group of learners. A study by the Nellie Mae Education Foundation (2015) examined the impact of technology in facilitating student-centred learning for STEM subjects. In the schools studied, learners experienced blended-learning practices, with teachers acting as facilitators. Learners also participated in experiential learning, supported by outside professionals. Compared to those involved in more teacher-centric, instructionist modalities, the study showed that individuals in the learner-centric programme achieved higher scores on science achievement tests. Gains were particularly significant among underserved students: female students, minority ethnic groups, and students receiving free or reduced-price lunches (indicating they come from low-income backgrounds).37

Another portion of the same study examined the impact of learner-centric practices on achievement and engagement in mathematics. In this study, teachers fell along a broad continuum of educational practice, implementing a mix of instructionist and more learner-centred techniques. Those in learner-centred classrooms reported higher levels of engagement and learning. The benefits of learner-centred practices were confirmed by quantitative measurements. Students in both learner- and teacher-centric classrooms took a portion of the PISA mathematics test. Holding a prior mathematics achievement as a constant, students in the more learner-centric classes scored significantly higher.38

CONCLUSION

While many educational authorities and institutions are calling for approaches that develop learners in a more holistic way, inculcating the full range of ‘21st-century skills,’ such an expanded mission will require a more comprehensive view of learning. Assessing the transference of information will not be enough. However, considering the acquisition of skills and the transformation of learner identity will also require an acknowledgment of learner agency and a reassessment of the role teachers play in the educational process. Constructionist approaches require a more robust definition of classroom community and a much greater emphasis on learner agency.

38 Nellie Mae Education Foundation (2015). “Centered on results.”
THERE PRIMARY LEARNING modalities have emerged that emphasise learner-centric construction as the primary mechanism for learning: problem-based, project-based, and ‘maker’ learning. These methods share a conviction that learning occurs and is solidified when learners apply what they are discovering to real-world contexts. However, while all three share this common foundation, they differ from one another in their understanding of the extent to which learners should create: is conceptualising a solution enough, or should learners create an actual, physical artefact? Should learners’ solutions remain ‘academic,’ designed only for the context of the learning experience, or should learners’ projects be deployed in a real-world context? Regardless, the results of incorporating these approaches, as borne out by research, offers an interesting counterpoint for schools employing more teacher-centric, instructionist approaches. Adopting these approaches produces a compelling series of benefits that move beyond informational transfer, resulting in gains in collaboration and social connexion, engagement, and critical thinking. They also prepare learners for ongoing discovery and provide them with skills and perspectives that benefit them in their post-school lives.

PROBLEM-BASED LEARNING: AN OVERVIEW

PROBLEM-BASED LEARNING (SOMETIMES referred to as ‘PBL,’ although this acronym is also used for project-based learning) is a learner-centred, constructivist educational framework in which learners build their understanding of a subject through engagement with a series of prompts. In problem-based learning, these prompts involve authentic, ‘ill-structured’ problems which learners must work through to design solutions or approaches. With the idea that “knowledge building is stimulated by the problem and [then] applied back to the problem,” problem-based learning frameworks expose learners to multiple

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problems, telling them less so they can discover more. However, most problem-based interactions fall short of having learners create or implement the solutions they design. Traditionally, these sorts of learning approaches focus on the informational processes learners engage in rather than their ability to apply their knowledge and understanding in realisable solutions.

Originally developed at McMaster University in the 1960s to make medical education more robust and engaging, problem-based learning presents learners with a scenario or case they must address. To find information that explains, answers, or responds to the problem presented, learners must conduct research in the content field, considering what they discover, using them to form hypothetical approaches, and then submitting these for evaluation by peers and teachers. Typically, students work in groups, with instructors acting as “facilitators (as opposed to knowledge disseminators) who support and model reasoning processes, facilitate group processes and interpersonal dynamics, probe students’ knowledge, and never interject content or provide direct answers to questions.”

Problem-based learning is designed to improve learners’ motivation, develop their higher-order thinking skills, and give them experience with ‘learning how to learn.’ By requiring learners to encounter authentic contexts and situations that they must research to gain understanding – without direct guidance or intervention by teachers – problem-based learning seeks to make learning a relevant preparation for real-world contexts. This emphasis on real-world relevance is also designed to generate positive engagement by learners and to improve their attitudes by providing a natural environment for developing problem-solving and life-long learning skills. Keziah’s research (2010), confirms the beneficial impact that problem-based learning can have. According to her study, learners in a problem-based course were more motivated to learn than those taught through lecture-format.

Evidence also demonstrates that problem-based learning improves the long-term retention of knowledge compared to more instructionist learning programmes, and problem-based learning also promotes better study habits among students. While there is no evidence to prove that problem-based learning enhances academic achievement as measured by exams for primary and secondary students, evidence suggests that it contributes to

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other important learning outcomes. Studies like Norman and Schmidt’s (1993) suggest that problem-based learning develops more positive student attitudes, fosters a deeper approach to learning, and helps students retain knowledge longer than they would through other forms of instruction.4

Hung, Jonassen, and Liu’s (2008) review of problem-based learning in primary and secondary (K–12) education showed positive effects in a variety of content areas, including mathematics, science, literature, history, and microeconomics. The researchers noted that these learning strategies proved effective in urban, suburban, and rural communities, and with a variety of student groups, including both low-income students and those considered gifted.5 In a study of at-risk female students in middle grades math and science classrooms, Cerezo (2004) determined that the adoption of problem-based learning resulted in an increase in students’ motivation, self-regulated learning, and self-efficacy.6

Although they are meant to refrain from direct intervention when using problem-based approaches, teachers’ influence on problem-based learning cannot be underestimated. Maxwell, Mergendoller, and Bellisimo (2005) revealed that teachers with more problem-based learning experience and stronger content backgrounds demonstrated greater effectiveness than less-experienced teachers when deploying student-centred pedagogies.7 With less-experienced teachers, problem-based learning proved, at best, only as effective as instructionist approaches. Successful implementation of constructionist curricula thus strongly depends on highly skilled teachers who can shape and oversee productive learning environments.8

The positive effects of problem-based learning are most clearly demonstrated in learning associated with professional skills and are particularly strong in the development of interpersonal skills.9 Prince (2004) found evidence that problem-based learning develops enhanced problem-solving skills in medical students and that these skills could be further improved by coupling problem-based learning with explicit instruction in problem-solving skills.10

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Among medical students, problem-based learning was significantly more effective than more instructionist methods in producing competent and skilled practitioners. Strobel and van Barneveld (2009) also demonstrated that problem-based learning promoted greater long-term retention of knowledge and skills acquired during the learning experience in medical schools than other methodologies.

Research comparing problem-based learning to more instructionist pedagogies also demonstrated increased overall student success. On average, those in problem-based medical programmes graduated more quickly than their colleagues in conventional schools, and problem-based schools retained on average 12% more students over a ten-year period compared to conventional medical schools. Vernon and Blake (1993) analysed 22 medical studies programmes from 1970 to 1992 and found that problem-based learning produced improved learner attitudes and opinions about the programmes. Data on learner attitudes, learner mood, and learner distress were consistently more positive with problem-based approaches than with instructionist methods. Additionally, the research also traced a statistically significant improvement in clinical performance and skills for learners exposed to problem-based curricula. Those who participated in problem-based learning demonstrated greater self-directed learning and placed greater emphasis on understanding over mere memorisation than those who did not.

Considering other fields of study, Arambula-Greenfield (1996) observed a preference by college students for problem-based science learning methods over instructionist pedagogies for both learning academic content and for practicing independent learning and critical thinking. In a study of engineering students, Galand, Frenay, and Raucent (2012) showed that whatever their previous level of achievement, students following problem-based curricula developed more new skills than those following more ‘traditional’ curricula, providing an important rationale for learners’ preferences.

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**DATA ON LEARNER ATTITUDES, LEARNER MOOD, AND LEARNER DISTRESS WERE CONSISTENTLY MORE POSITIVE WITH PROBLEM-BASED APPROACHES THAN WITH INSTRUCTIONIST METHODS**


In contrast, another body of research shows problem-based learning having little impact on student achievement. In a review of medical education literature, Colliver (2000) found no convincing evidence that problem-based learning improves either learners’ knowledge base or clinical performance. He concludes that while problem-based learning may provide a more challenging, motivating, and enjoyable approach to medical education, its broader educational effectiveness, when compared to traditional methods, is uncertain. Wilder’s (2015) systematic analysis of problem-based learning for K–12 students concluded that while most of the studies observed problem-based approaches having a positive impact on academic achievement, it is not possible to claim with confidence that problem-based learning is more effective in increasing content knowledge. Likewise, Sungur, Tekkaya, and Geban (2006) found no significant difference in the acquisition of factual knowledge between those taught by problem-based methods and those taught through lecture. However, while there was no difference in the recollection of factual knowledge between the two groups, researchers established that learners taught by problem-based methods scored significantly higher on assessment items measuring their ability to organise and integrate knowledge.

The relative scarcity of peer-reviewed studies investigating the effectiveness of problem-based learning for improving academic achievement at the secondary level described by Wilder (2015) and others might give educators pause—especially given the increased prevalence of this instructional method in primary and secondary contexts. However, one explanation for the lack of consensus about the impact of problem-based learning may derive, in part, from the fact that research often creates unproductive distinctions between learner achievement as measured by retention of knowledge and learner achievement as measured by the acquisition of critical and interpersonal skills. The clear message is that the educational community needs more clarity about what we mean by ‘learner achievement.’ For example, in much of the research, academic achievement is equated with the ability to recall conceptual and factual knowledge. While some research attempts to measure other skills, these measurements are not necessarily understood to be indicative of academic achievement. Since one of the chief advantages offered by learner-centred, constructionist approaches involves the development of a range of skills above and beyond content knowledge –

THE EDUCATIONAL COMMUNITY NEEDS MORE CLARITY ABOUT WHAT WE MEAN BY ‘LEARNER ACHIEVEMENT’

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and collaboration, critical thinking, problem-solving, decision-making, and self-directed learning\textsuperscript{21} – segregating these achievements from accounts of formal academic progress helps to obscure and confuse learning gains that might otherwise be clear.

\textbf{PROJECT-BASED LEARNING: AN OVERVIEW}

\textit{Like problem-based learning, project-based learning (also sometimes referred to as ‘PBL’) is a learner-centred approach focused on engaging learners in constructing knowledge about a topic. It is structured to require learners to draw upon their prior knowledge and skills as they address meaningful (and ideally, real-world) challenges in the classroom. Unlike problem-based learning, which asks learners merely to hypothesise or think through a problem, project-based learning asks learners to demonstrate their thinking in the creation of a solution or artefact. Within the project-based learning framework, learners design and create projects meant to address a challenge that is often posed by a teacher or external entity, although learners also sometimes participate in the selection of the problems they address. As Blumenfeld, et al. (1991) describe it:}

\begin{quote}
Project-based learning is a comprehensive perspective focused on teaching by engaging students in investigation. Within this framework, students pursue solutions to nontrivial problems by asking and refining questions, debating ideas, making predictions, designing plans and/or experiments, collecting and analyzing data, drawing conclusions, communicating their ideas and findings to others, asking new questions, and creating artifacts.\textsuperscript{22}
\end{quote}

Project-based learning works to reinforce knowledge development through both independent exploration and cooperative group work. To maximise learning, it emphasises learner agency and collaboration, with assessments based on authentic performances and projects rather than on the repetition of information that was delivered by a teacher.

In investigating a problem and designing and making a solution, learners are asked to acquire broad and interconnected understandings of key principles and concepts. This stands in contrast to the narrowly-defined, disciplinary isolation typically called for in instructionist learning. By placing learners in environments where they must develop projects contextually to address a challenge, project-based learning requires considerable knowledge, effort, persistence, and self-regulation on the part of learners. And since teachers play a critical role in shaping the challenges that learners will address, they must be thoughtful, strategic, and


intentional in the way they design challenges and interact with learners. As John Dewey put it in *My Pedagogic Creed* (1897),

> The teacher is not in the school to impose certain ideas or to form certain habits in the child, but is there as a member of the community to select the influences which shall affect the child and to assist him in properly responding to these. [...].
> I believe that the teacher’s business is simply to determine on the basis of larger experience and riper wisdom, how the discipline of life shall come to the child. [...].
> I believe, therefore, in the so-called expressive or constructive activities as the centre of correlation.\(^{23}\)

Because the processes of research, design, development, and production are crucial in project-based learning, students must engage actively over an extended period of time. This need for substantive, dedicated time to consider and create is even more apparent when students work on projects designed to link classroom experiences with real-life situations outside of school. The need for long-term interaction coupled with the variety of activities associated with project-based learning offers important benefits for a wide array of learners: unlike the more limited group of learners who excel at instructionist learning, project-based learning welcomes and can serve learners possessing a more diverse set of skills and abilities. The adaptability of projects and the participation of learners in more stages of the learning often means that more learners—even those not “good at school”—can succeed.

Project-based learning is built around three essential elements or stages. First, learners are presented with a question, problem, or issue. This prompt serves to organise and drive learning activities, setting learners on a specific design path. They must then create a series of products, culminating in a final project that addresses or works to resolve the question, problem, or issue. To ensure the agency of learners, the initiating prompt cannot be so constrained or simple that the outcomes are predetermined. Prompts must be complex enough to allow learners room to develop their own approaches and responses and must be formed around the learner’s freedom to generate the ideas and solutions that lead to a final project. Such freedom is essential, because it is through generating and pursuing ideas that students construct their knowledge, leading to learning.\(^{24}\)

Although they are certainly not the summative artefacts at the centre of many instructionist classrooms, projects are central to this form of learning. However, in one sense, the projects that students develop are irrelevant. In project-based learning, the projects serve as ‘formative’ vehicles for learning. They provide the infrastructure in which


\(^{24}\) Blumenfeld, et al. (1991) “Motivating project-based learning: Sustaining the doing, supporting the learning.”
learning occurs, yet the specific details of the project are less important than the structural framework of problem-solving that learners must navigate. Essentially, projects are a mechanism designed to allow learners to experiment, use simulations, address authentic issues, and work with peers and community members in the pursuit of knowledge.

**PROJECT-BASED LEARNING: RESEARCH AND ASSESSMENT**

Research on project-based learning indicates that it enhances student performance, motivation, and engagement. This approach drives increased teacher/student interaction and promotes acquisition of 21st-century skills: creativity, critical thinking, collaboration, cooperation, and communication. For example, Mills and Treagust’s (2003) study of the impact of project-based learning on engineering students demonstrated that students who participated in project-based learning were generally more motivated and demonstrated better teamwork and communication skills. They possessed a better understanding of how to apply their knowledge in practice and better understood the complexities of other issues involved in professional practice. However, this study also demonstrated that project-based learning did not necessarily improve the students’ content knowledge. In fact, it suggested that some students involved in project-based learning may graduate from their courses with a less rigorous understanding of engineering fundamentals.25

Research by Dole, Bloom, and Doss (2017) on the implementation of project-based learning among students in grades 1 to 9 showed significant improvements in motivation, attitude, and engagement. During interviews, teachers described these improvements, noting that students spent more time in and outside of class discussing their topics with peers and parents. The teachers also noted increased enthusiasm in the way learners approached and pursued topics, using personal time to conduct extra research. This increase in engagement and enthusiasm resulted in situations where individuals did not realise how hard they were working or how much they were learning. The teachers interviewed in the study described an increased tendency by learners to work toward mastery rather than simple task completion, with learners becoming so immersed in their activities that they often asked to spend extra time on assignments. While this study did not measure the impact of project-based learning on test scores or other traditional forms of assessment, the research demonstrated improvements in learner motivation, attitude, and engagement—along with the development of both collaboration and leadership skills.26

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Like Dole, Bloom, and Doss, Ilter (2014) also found increased motivation when a 4th-grade social studies class employed project-based learning. Unlike Mills and Treagust, Ilter found that learners’ conceptual understanding of the subject increased under a project-based learning framework. In addition, project-based learning positively affected learners’ conceptual achievement and motivation to succeed academically, compared to those who were taught by more delivery-based, instructionist methods. Ilter’s results mirrored Gultekin’s (2005) research on the impact of project-based learning on grade 5 social studies students. Gultekin found that learners who were exposed to project-based learning displayed improved research skills, better problem solving, and more frequent use of higher-order critical thinking.

Kaldi, Filippatou, and Govaris (2011) examined the effectiveness of project-based learning on primary-school students, specifically examining this approach’s impact on their content knowledge and their attitudes about self-efficacy, task value, group work, teaching methods, and their perception of peers from diverse ethnic backgrounds. The study found that learners who were exposed to project-based learning demonstrated increased content knowledge, enhanced motivation, and more productive group work skills. Significantly, learners exposed to project-based learning were more likely to develop positive attitudes toward peers from a different ethnic background.

In a study that measured the impact of project-based learning on mathematics problem-solving and resilience, Speziale, et al. (2016) found that project-based learners demonstrated greater levels of engagement and motivation and outperformed their peers who were subject to more instructionist pedagogies. They found that project-based learning promoted learning in a more integrated, holistic way than other pedagogical programmes. Learners in problem-based classes demonstrated a greater ability to solve problems and a deeper level of understanding that crossed content areas.

Boaler (1999) conducted a study comparing two schools in England—one whose curriculum was project-based and another whose curriculum was instructionist. The schools were demographically similar (students were comparable in gender, ethnicity, and social class), and both schools had used similar approaches to mathematics instruction in prior years. In addition, both schools had showed...

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similar achievement for mathematics on a range of tests, with results from a national, standardised test of mathematics proficiency revealing no significant differences among the scores of students enrolled in either school. However, Boaler’s study revealed that once learners were exposed to project-based learning, they began to regard mathematics as a dynamic, flexible subject requiring exploration and thought, as compared to those at the instructionist school, who viewed mathematics as boring and tedious. Moreover, learners at the project-based school performed as well or better than those at the instructionist school on tasks that required rote knowledge of mathematical concepts, with three times as many students at the project-based school attaining the highest possible grade on the national examination as compared to those at the instructionist school. Overall, significantly more learners at the project-based school passed the national examination and excelled on national exam scores at the end of the three-year study than those enrolled in more ‘traditional’ mathematics courses.\(^{31}\)

Duke, et al. (2017) assessed the results of project-based learning in high-poverty schools with historically low performance on state tests. Their research demonstrated that project-based learning improved student achievement on tests when compared to those who received teacher-driven instruction in these high-poverty, low-performing school districts. The research team found statistically significant differences favouring the project-based group over the control group. In social studies, the project-based group demonstrated gains 63% higher, and in informational reading, 23% higher than those who did not experience project-based learning.\(^{32}\)

Harris, et al. (2014) conducted a comprehensive study of project-based versus instructionist learning in science involving 3,000 middle school students and 100 teachers in a large and diverse urban school setting. Their work supported three major findings. First, learners in the project-based curriculum outperformed those in the instructionist setting on post-unit assessments. Second, the project-based approach resolved disparities in scoring among learners from underrepresented demographics as well as between males and females. Finally, this study showed that teachers were more likely to engage with learners in project-based classes, with teacher/learner interactions increasing significantly over time as compared to those involved in instructionist classes.\(^{33}\)

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32 Duke, N., A. Halvorsen, S. Strachan, J. Kim, & S. Konstantopoulos (2017). “Putting PBL to the test: The impact of project-based learning on second-grade students’ social studies and literacy learning and motivation.” Unpublished research. https://docs.google.com/viewer?pid=sites&srcid=dW1pY2guZWR1fG5rZHVrZXxneDo0ZWQ1ZTk3NTFmZDI4ZTg5
However, not all studies have shown the same positive results. Johnson and Cuevas (2016) examined the impact of project-based learning on students in 6th-grade English language arts classes. In this study, project-based learning did not demonstrate any significant advantages for learners in terms of reading motivation or perceptions of critical thinking. Although it is difficult to generalise from a single study, these findings might suggest that project-based learning does not offer the same advantages in terms of increasing student motivation and engagement in a language arts class that it does in social studies, science, or mathematics classes.  

‘MAKER’ LEARNING AND ‘MAKER SPACES’: AN OVERVIEW

The ‘maker movement,’ like project- and problem-based learning, is another example of a learner-centric, active-learning methodology. Another form of constructionism, ‘maker’ education is based on learners developing an idea and then designing and creating an external representation of that idea. As with other constructionist approaches, it is learner driven, with learner agency at its philosophical core. However, perhaps more than any other constructionist framework, maker education emphasises “constructing knowledge through the act of making.”

‘Making’ refers to a broad set of activities that can be designed with various learning goals in mind. It can take place in many kinds of locations that are collectively labelled ‘maker spaces.’ Classrooms, museums, libraries, studios, homes, or garages may all serve as maker spaces. As Fleming (2015) notes in her useful guide, what distinguishes these spaces is not where they are but how they are equipped and used: maker spaces offer access to tools and resources designed to empower learners who are working to turn knowledge into action. Additionally, more than either problem- or project-based learning, maker learning takes very seriously the social aspect of constructionism. As Donaldson (2014) argues “learning happens best when learners construct their understanding through a process of constructing [objects] to share with others.”

Maker learning has become more prominent in recent years, moving beyond long-standing associations of ‘making’ with vocational disciplines to encompass a broader segment of the learning spectrum. However, while the value of ‘making’ is well

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recognised, educators are still wrestling with ways to integrate this project into the more formal curricula that dominate most schools. Part of the reason for this friction is that ‘making’ bridges the divide between formal and informal learning, challenging practitioners and educators to think more strategically and expansively about where and how learning happens and making integration of this approach more difficult.38 Maker education’s blurring of the lines between formal and informal learning also means that some of the mechanisms with which schools have sought to measure or guarantee learning must be reconsidered. Traditional assessment systems, for example – designed largely to measure the accurate reception and replication of information delivered by teachers – typically lack a mechanism for tracking the learning that happens in the broader contexts of ‘making.’ Instead of an emphasis on assessing knowledge in the abstract – testing ‘knowledge as knowledge’ – ‘making’ requires a concrete demonstration of how learners are using knowledge or what they can do with the knowledge they have acquired, and this more holistic approach adds significant complexity to assessment.

Maker education works to prepare learners for the real world by giving them opportunities to approach, consider, and address real-world challenges of their own choosing, making whatever solutions or projects they feel appropriate to do so.39 Because of this, as pioneer of the maker movement, Dale Dougherty, explains, when an individual generates a project, the project itself demonstrates what the individual has learned, and thus provides the best evidence of learning.40

Maker spaces are frequently informal, collaborative environments designed for creative production. Often associated with people working in the ‘STEAM’ disciplines (science, technology, engineering, arts, and mathematics), maker spaces encourage participants of different ages and levels of experience to blend digital and physical technologies as they explore ideas, learn technical skills, and create new projects. Maker spaces typically incorporate new technologies and innovative processes, encouraging participants to take advantage of these resources as they design and build.41 The essential characteristic of maker spaces is that they

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all involve and facilitate making, helping people develop an idea and construct it in some physical or digital form.\textsuperscript{42} In order to develop their projects, learners in these spaces must use a range of knowledge and experience holistically, often crossing disciplinary boundaries and learning to work with a range of tools, materials, and processes.\textsuperscript{43} By design, maker spaces are therefore ideal venues for the development of projects that do not fit neatly into narrow disciplinary or subject areas. They encourage learners to collaborate, remix, extend, and invent, often combining multiple approaches and knowledge areas in their projects.

By fostering this sort of multifaceted, multidisciplinary approach, maker education seeks to engender curiosity, tinkering, and iterative learning, leading to more robust thinking through better questioning and more thorough, ongoing exploration. As a learning approach, ‘making’ is designed to foster enthusiasm for learning, self-confidence, and natural collaboration.\textsuperscript{44} For this reason, community in the maker space serves as yet another crucial resource for the achievement of learning goals. Ultimately, the aim of maker education and educational maker spaces is the generation of learners who are determined, integrative, creative, critical, and intensively collaborative.

\textbf{‘MAKER’ LEARNING AND ‘MAKER SPACES’: RESEARCH AND ASSESSMENT}

Like other constructionist approaches, maker education is centrally focused on learner-centred inquiry. Maker classrooms are ‘active,’ characterised by learners who

> “often work on multiple projects simultaneously, [supported by] teachers unafraid of relinquishing their authoritarian role. Collaboration between students is flexible and teachers experience a seamless metamorphosis between mentor, student, colleague, expert, and personal shopper, all in service of their learners.”\textsuperscript{45}

Because of its emphasis on flexibility and plurality, maker education often seeks to blur (or outright ignore) the distinctions between the ‘humanities’ (including the domains of arts, humanities, and the social sciences) and the ‘sciences’ (including the domains of engineering, mathematics, and science). Just as importantly, maker learning works to break down traditional distinctions between vocational and academic education.\textsuperscript{46}

\begin{itemize}
\item \textsuperscript{42} Sheridan, et al. (2014). “Learning in the making.”
\item \textsuperscript{43} Sheridan, et al. (2014). “Learning in the making.”
\item \textsuperscript{44} Kurti, et al. (2014). “The philosophy of educational makerspaces.”
\item \textsuperscript{46} Stager (2014). “What’s the maker movement and why should I care?”
\end{itemize}
This expansive definition means that ‘maker’ learning seeks to produce far more than a completed project at the end of a unit of learning. Its chief educational objective is to produce a community of makers who, in turn, help others join the community and become makers themselves. The community becomes transformative, leading and affecting change. In this enterprise, the maker space serves as both the site of and the vehicle for learning—a space that shapes learners’ expertise and offers them opportunities to demonstrate that expertise by guiding others. ‘Maker’ learning instils in its community an aptitude to be creative, to innovate, to work collaboratively, and to be technologically literate. For authors like Stager (2014), such qualities are integral to modern learning.47

The diversity and emphasis on productivity of maker learning and maker spaces means they can be adapted to fit many different learning contexts. Recently, maker spaces have become particularly popular in universities—especially in engineering and design departments. A 2014 study of maker spaces at the top 100 engineering universities in the United States revealed that 35 of them had at least one maker space, while two universities had two maker spaces each and one university had three.48

While data on increased academic achievement due to ‘making’ is not conclusive—in part due to its relative newness—research indicates that it has a positive impact on learners. Clapp, et al. (2017) found it helped with the promotion of growth mindsets, personal agency, and student empowerment.49 Studies have also pointed to a connection between maker activities and improved spatial reasoning (Katsioloudis, et al. 2015).50 In university programmes, Longo, et al. (2017) showed that maker spaces can increase diversity, access, and retention among students, also leading to increased admissions. Their research indicated that ‘making’ positively impacts learner creativity, confidence, initiative, and innovative thinking, and to a lesser extent demonstrated that it can increase student performance and grades.51

Because maker spaces introduce learners to tools, skills, and techniques as they work in them for both educational and leisure purposes, ‘making’ can also act as a bridge between education and employment. Since many high schools have eliminated ‘shop’

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classes, many learners who have not enrolled in a technical school program have had fewer opportunities to use mechanical tools. Maker spaces fill this gap, providing learners with opportunities to learn practical skills. While this may offer them a chance to develop skills that enable them to enter the workforce in new, more practically focused fields, the chief value of ‘making’ lies in the opportunities it gives learners to recognise the connections between the knowledge they are developing and the physical world around them. By manifesting their knowledge in real-world, physical contexts, learners can refine and situate their learning in ways not offered by more instructionist or information-centric methods.

**ON THE BENEFITS OF INSTRUCTIONISM**

While significant amounts of research support constructionist learning methods, other studies support the continued deployment of instructionist pedagogies. For example, according to Kischner, et al. (2006), controlled experiments almost without exception indicate that learners benefit from receiving explicit instruction about what to do and how to do it when they encounter unfamiliar topics. Other empirical studies make a broader, research-based case, arguing more generally against the use of learner-centric, constructionist methodologies. For example, Mayer (2004) concluded that the debate about discovery has been replayed many times in education, but each time, the research evidence has favoured a guided approach to learning. [...] Today’s proponents of discovery methods, who claim to draw their support from constructivist philosophy, are making inroads into educational practice. Yet a dispassionate review of the relevant research literatures shows that discovery-based practice is not as effective as guided discovery. (18)

Studies conducted almost a decade apart by Hardiman, Pollatsek, and Weil (1986) and Brown and Campione (1994) observed that when students learn science in classrooms with constructionist or experiential methods and minimal feedback, they often become lost and frustrated, and this confusion can lead to misconceptions. Other

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researchers agree. For instance, Moreno (2004) concluded that students learn more deeply from strongly guided learning than from self-discovery.56

In another study, Klahr and Nigam (2004)57 tested not only whether science learners learned more information via discovery than via direct instruction, but also, once learning had occurred, whether the quality of learning differed. Their findings were unambiguous. Direct instruction—when it involved considerable guidance, including examples—resulted in more informational learning than a learner-centric, discovery approach. Those relatively few students who learned via self-directed methods showed no signs that their learning was of superior quality.

Studies by Perkins58 (1991) and Roblyer59 (1996) also examined evidence about the results of learner-led methodologies, this time in the fields of instructional design and instructional technology studies. Both researchers concluded that the available evidence did not support the use of minimally guided, discovery-based approaches and both suggested that some form of stronger guidance was necessary for both effective learning and informational transfer.

Kirschner, et al. (2006) similarly argue that evidence supporting the benefits of these learning approaches is sparse despite a half-century of advocacy for instructional methods involving minimal guidance. In addition to claiming that evidence supports direct instruction and strong guidance for the instruction of novice and intermediate-level learners, these researchers contend that strong guidance typically proved to be just as effective as unguided, discovery-based approaches, even for students with considerable prior knowledge. Their research suggested not only that unguided instruction was typically less effective, but they also argued that such instruction might produce negative results, resulting in learners acquiring misconceptions or incomplete or disorganised knowledge.60 As these researchers observed, these deficiencies were often the result of practitioners who favoured limited guided instruction, paying little attention to the characteristics of and intricate interplay between working memory and long-term memory.

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The researchers concluded that evidence demonstrates a need for greater guidance than is provided in many learner-centred pedagogies, including problem-based learning interventions. They believed that the strategies recommended for problem-based learning are almost impossible for most educators to implement, in part because these learning approaches require learners to engage in cognitive activities that the researchers believed were unlikely to result in effective learning.\(^61\)

In another study, Aulls (2002) observed a number of teachers as they implemented constructivist activities in their classrooms. He discovered that teachers tended to introduce ‘scaffolding’ when students failed to make progress in a learner-centric, discovery-based setting. While sometimes associated with instructionist teaching methods, scaffolding can be a positive and enabling experience for learners of all ages. This is certainly the view of socio-constructivists like Vygotsky (1978)\(^62\) and Rogoff (1994)\(^63\) who observed that learners need an element of support, a goal, or guiding questions for effective learning to take place. To remove guidance completely can be ineffective for learners who are not intrinsically motivated or those who need additional support. Bowler & Champagne (2016) identify the importance of question prompts as a verbal tool that can reveal learners’ self-regulation, self-awareness, reflection and reflexivity in the maker process:

Since the time of Socrates, educators have known that question prompts are a useful tactic for provoking critical thinking. Practice that is guided by skillful questioning from a teacher (or, in the case of the maker space, a mentor) can help learners analyse their own thinking processes, see connections and build new understanding. (119)\(^64\)

The intention is that with continued practice and modelling, learners can begin to ask questions themselves without the need for intervention or expert help. In so doing, they can then help less experienced or apprentice learners in the process. Those teachers whose students achieved all of their learning goals spent more time in direct instructional interactions with students than teachers whose students did not achieve their goals.\(^65\)

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Some of this may be due to the impact of direct instruction on learners’ cognitive loads. According to Moreno (2004), scaffolding with explanatory feedback, which reduced cognitive load for learners by offering them guidance during an activity, provided better results than learners who received only corrective feedback. Similarly, Tuovinen and Sweller (1999) found that the reduced cognitive load of ‘worked examples’ provided better results than the learner-centric exploration of ‘discovery learning’ for novice learners.

However, while these studies might seem compelling, it should be noted that their primary measurement of success involves informational transfer rather than the development of skills, critical thinking, or the ability to apply information in appropriate contexts. The issue of scaffolding or providing instruction to students might be less pertinent if learners (or their parents) were not as centrally focused on passing tests and getting good grades. If education’s chief task is seen as the transference of information rather than the fashioning of more holistic learning and the long-term development of both knowledge and the ability to put it into practice, these studies might appear more conclusive. In effect, the informational emphasis reflected in these studies may be setting up a tautology or feedback loop: if we decide that the focus of education should be primarily informational, and based on that, if we test only the transference of information between teachers and learners, then the terms we set up may artificially favour one learning approach over another. In effect, we may see broad validity in approaches that are only narrowly applicable. On the other hand, if we start with a larger and more holistic definition, we would likely find less validity in approaches that primarily facilitate informational transfer.

What is clear is the need for more critical understanding of what we mean and understand when we use the term ‘instructionism,’ especially within the frame of constructionist learning and theory. There is little question, for example, that guided direction and learner scaffolding provide support to novice learners and those who lack confidence, no matter whether the intention is to pass an exam or learn in a more holistic manner. It is therefore artificially narrow and doctrinaire to suggest that such practices have no place in an educational approach that is broadly constructionist. Regardless of how much we emphasise learner agency and discovery learning, the teacher or ‘guiding participant’ is nonetheless an integral part of the learning process and cannot be dismissed or removed without altering the environment—and the learning outcomes.

Our goal rather is to suggest that learners benefit from all kinds of activities and interventions. Adding learner-centric constructionist strategies to what would otherwise be a more teacher-led model emphasising the consumption and repetition of information offers significant opportunities to define learning more holistically, resulting in a more engaging and effective learning environment.


One of the key factors in the success of constructionist learning methodologies involves their dual emphasis on community and experience. Built on collaboration, social knowledge construction, and the value of debate, discussion, and negotiation, these approaches offer learners an opportunity to take on multiple interdependent roles as they design and construct projects. At the same time, their emphasis on construction and making gives learners a chance to move beyond a mere intellectual appreciation of a discipline, experiencing it as implementors and practitioners. Because of their inherently dialectical and experiential properties, constructionist learning approaches expose learners to more than the mere transfer of information: working through these approaches, learners witness different behaviours and can try out different identities, developing content-focused and collaborative skills as they work together. Being intentional about both social and experiential factors in the design of constructionist learning can increase the impact and the efficacy of these learning programmes, giving learners valuable opportunities to grow.

Social Learning Theory and Collaborative Learning

As developed by Albert Bandura (1925–), social learning theory contends that learners can internalise new patterns of behaviour through observing others as well as by direct instruction or experience. When individuals observe others who model a particular behaviour, they can observe how that behaviour is performed: then, on later occasions, these observations can function as a guide, enabling them to replicate what they have observed. Although it is sometimes ignored as a factor, modelling is therefore an indispensable mechanism for learning, and for Bandura and others, this means that learning is inherently social. As he demonstrated, even if it is possible to convey information through other means, providing an appropriate model considerably shortens the process of learning.¹

Bandura believed that four conditions are necessary for modelling to lead to productive learning.

**Attention:** For learning to occur, observation alone is not enough. Learners must attend to—and recognise—the essential features of the model’s behaviour, identifying the component parts and understanding how they combine together to create the behaviour;

**Retention:** Learning requires long-term retention of information about the behaviours or activities that have been modelled and observed;

**Reproduction:** To reproduce behaviours (and demonstrate learning), individuals must assemble a given set of component responses according to modelled patterns. The amount of observational learning people can exhibit behaviourally depends on whether or not they have acquired and can replicate the component skills appropriately;

**Reinforcement and motivation:** It is possible for learners to acquire, retain, and have the ability to replicate the components of a modelled behaviour, yet be unable or unwilling to demonstrate their learning if the behaviour is negatively sanctioned. On the other hand, in the presence of positive incentives, learned behaviours which otherwise might have remained unexpressed may be translated into action and adopted by learners.²

Because of its model of observation, internalisation, and expression, social learning theory describes a supportive atmosphere for learner-centred education and offers a useful means for observing learners’ growth. For example, Carrington and Selva’s (2010)³ study explored the ways social learning theory informed the reflection process used by a group of pre-service teachers considering their growth when they engaged in service learning. The study showed that the implementation of this socially informed reflection taught the learners important critical thinking skills. A study by Palloff and Pratt (2007)⁴ concluded that the scaffolding of collaborative skills helped learners achieve a deeper level of knowledge while also helping to facilitate a move from independence to interdependence.

Kumpulainen and Way (2002) assessed the impact of social learning on language development, comparing teacher-centred (instructionist) with peer-centred (social and collaborative) classroom organisations among primary school children. Their study demonstrated that while the functions of the children’s spoken language were restricted in the teacher-centred class, the quantity and quality of the children’s talk increased in the

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peer-centred class. Although some might otherwise be tempted to dismiss social learning as a factor, Kumpulainen and Way showed a strong correlation between group discussions and children’s oral language development.5

Mainemails, Boyatzis, and Kolb (2002) examined the impact of collaboration on learning geometry. Their research showed significant benefits obtaining from a social learning environment designed to engage learners in communal activities and encourage discussion, negotiation, and collaboration as learners developed geometrical thinking. The researchers found that this setting encouraged intensive task engagement, the formation of critical skills (including reasoning, problem posing, and problem solving), and the internalisation of productive collaboration skills. Designing learning tasks to incorporate and leverage small group interactions offered learners opportunities to develop mathematical concepts, to model and observe mathematical behaviours, and to develop and demonstrate mathematical thinking skills.6 Small ensemble and peer-led learning can help students build confidence, share knowledge and create frames of reference that create a more effective and enjoyable learning experience.

**EXPERIENTIAL LEARNING AND THE ‘CRUCIBLE’ OF EXPERIENCE**

Educators define ‘praxis’ as the unification of knowledge and behaviour that learners develop as they move cyclically between reflection and action. As they navigate the tensions between these counterbalancing processes, they forge new skills, transformed by what has come to be known as ‘experiential learning.’7 David Kolb (1939–) describes experiential learning as a holistic, integrative learning methodology that combines experience, cognition, and behaviour.8 In his conceptualisation, learning is a process where learners derive concepts and continuously modify them through experience. One reason that project-based and ‘maker’ learning may be so effective derives from the ways these approaches scaffold and depend on experience. Requiring learners to put their ideas into practice, and thereby to confront missing or incorrect concepts through the experience of building solutions, corresponds with Kolb’s definition of experiential learning.

However, the ideas behind experiential learning are not new. Elements can be found in the works of Kurt Lewin, John Dewey,
and Jean Piaget. For example, Lewin (1890–1947) describes learning as a cyclical process where concrete experiences form the mechanism for transforming observations and reflections into abstract concepts and generalisations, allowing them later to be applied in new situations. For Lewin, learning emerges as a result of the productive conflicts between concrete experience and abstract concepts and between observation and action. Dewey (1859–1952) asserted that learning is a process involving observation followed by an exploration of what has happened in the past in similar situations so as to develop judgment—which he classifies as a combination of what is observed with what is recalled. This judgment must then be put it into practice, offering learners the opportunity to continue refining their knowledge. By translating their judgment into experience, learners solidify their learning. Piaget (1896–1980) stressed that learning is a mutual interaction between experience and conceptualisation where learners adapt concepts to fit their experiences and extrapolate from their experiences to develop concepts. For Piaget, the conflict between accommodating ideas to the external world and assimilating experience into existing conceptual structures is the chief context in which learning takes place.

These theoretical models lay out the basic framework of experiential learning, which may be summarised as follows:

**In experiential learning,**

- **Learning** is best defined as a process rather than a product or outcome;
- **Learning** must continuously be grounded in experience, deriving from and constantly being tested out and refined in the experience of the learner;
- **Learning** requires the resolution of conflicts between the dialectically opposed modes of conceptualising/experiencing and acting/reflecting, pursuing congruence between both modes through continual adaptation and refinement;
- **Learning** is a holistic process of ongoing adaptation to the world involving the whole person: thoughts, feelings, perceptions, and behaviours. Seen this way, it encompasses far more than what is encountered or generated in a classroom. Learning is understood to touch all aspects of life across all life stages. Considered holistically, learning is best seen as a conceptual bridge that unites diverse life events, functioning continuously as an organic process;
- **Learning** involves interactions and exchanges between the person and the environment. In experiential learning theory, the transactional relationship between the individual and the environment is epitomised by the dual meaning of the term ‘experience’:

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refers both to a person's internal state ("I possess this level of experience") and to interactions with the objective environment ("I am experiencing this");

Learning is the process of constructing knowledge, which results from the interplay between personal knowledge – which is the accumulation of an individual's subjective life experiences – and social knowledge – which is the 'objective' accumulation of previous human cultural experiences.

Attempts to validate the impact of experiential learning have not been entirely successful. However, a 1994 meta-analysis of 275 dissertations and 624 articles that used a mixture of qualitative, theoretical, and quantitative analyses of experiential learning concluded that there was sufficient evidence to support its ongoing implementation for learning.\(^\text{10}\) A study of experiential learning by Mainemails, Boyatzis, and Kolb (2002)\(^\text{11}\) determined that learners who integrated the dual dialectics of conceptualising/experiencing and acting/reflecting were more flexible in both dialectical dimensions, developing important capabilities related to each dimension. For example, the researchers concluded that individuals who focused on conceptualising their learning developed higher analytical skills, while those who focused on experiencing developed higher interpersonal skills.

Abdulwahed and Nagy (2009) examined a model for laboratory education based on Kolb’s experiential learning theory, assessing the model's impact on educational practices and learning outcomes. Their research proved that poor classroom implementation of the theory yielded poor learning outcomes. A better learning outcome was only possible when the educational practices were well-designed, well-developed, and congruent with the theory.\(^\text{12}\) Herein lies a central challenge for designing and practicing new learning models: the transformation of theory into practice can be influenced by many factors—including professional development, school culture, disciplinary practice, and teacher experience—all of which can impact effectiveness. From a research standpoint, the difficulty in assessing learning increases exponentially with these factors, making it more difficult to find definitive answers.

**COMPUTING TECHNOLOGY: COMPLEXITY AND PROMISE FOR EDUCATION**

Years before it became fashionable to believe ‘everyone can code,’ Seymour Papert proposed using computers to support education, contending that learners’ attention could be

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held for prolonged periods if they were making software rather than simply using it. Even if they considered the content of the educational software to be boring, Papert believed that giving learners the power to apply their learning in the design of applications would result in engagement.\textsuperscript{13} As he described it, computers were ‘material to be messed about with,’ a resource that encouraged exploration and learning.\textsuperscript{14} Although integrating them posed technological, procedural, and pedagogical challenges at the time, Papert believed these were worth overcoming because incorporating both computer technology and what we now call ‘coding’ increased the willingness of learners to learn.\textsuperscript{15} Papert believed the computer was a perfect tool to stimulate learning, “because it can take on a thousand forms and can serve a thousand functions, it can appeal to a thousand tastes.” However, he stressed that the main focus should not be on the technology itself nor on the applications and software learners generated, but on the learners’ minds—on their growth and development.\textsuperscript{16} In this way, Papert believed computers could give learners the opportunity to control their learning, providing them with a vehicle for testing and refining their experiences and understanding in a way that could be shared with others.

Rather than a group of adults, technologists, or education experts, Papert believed that children would lead the computer revolution in education. Children, having gained greater experience using computers than their teachers, would demand that more be done to incorporate them in their education:

\begin{quote}
\textit{this technology, the personal computer, is not a teacher’s technology, it’s a learner’s technology. And it’s a technology that can be appropriated, taken over by young people, who can use it to feel the power of their own individual intellectual personalities. And we’re beginning to see, coming into school, more and more kids who have had computers from the day of their birth, who’ve gotten used to using them, many of them not very well. But some of them have used them to have very, very rich learning experiences – [and we’re] beginning to get a peppering of these kids in our classrooms. And that is a real army to bring about change. I call it ‘Kid Power.’ Kids coming into school and saying, “We want something better than this, and not only do we want it… [...] We’ll show you how to do it. We’ll help you.” (part 2)\textsuperscript{17}
\end{quote}

\begin{itemize}
\item[]\textsuperscript{15} Papert & Harel (1991). “Situating constructionism.”
\end{itemize}
For Papert, the computer was the perfect way to integrate social and experiential learning. More importantly, it was also the perfect tool to drive a radical revolution in education, overturning the dominant mechanisms of instructionism so they could be replaced by personalised, learner-centric approaches built around enhanced learner agency. However, Papert was aware of the tendency for adults and those in authority to conceptualise ‘computer literacy’ as simply another content area to add to a traditional curriculum. Formulated this way, computing technology would become yet another mechanism for content delivery instead of a resource that facilitated meaningful learning and the creation of knowledge. Because of its perception as an elite subject requiring high levels of expertise rather than something even kids could ‘mess about with,’ Papert warned that computer-aided instruction had the danger of amplifying the rote and authoritarian character of some teachers. This further calcification of the teacher as authoritative-content-deliverer was precisely what Papert and many other contemporary critics saw as the most prevalent negative characteristic of school and the aspect most in need of change. Reinforcing it was, quite literally, the opposite of what he intended.

For Papert and for the generation of teachers, theorists, and researchers who are following in his footsteps, the area of greatest potential for computing technology is when it is used to alter and improve the nature of the learning process. Shifting the balance from a model where students are expected predominantly to receive and consume content knowledge to one where learners actively participate in the construction and design of knowledge not only serves a powerful educational purpose; it also mirrors in the classroom the very kind of decentralised, collaborational, constructionist environment that dominates today’s online world. Just as this emerging online ‘culture’ has challenged earlier informational and consumer enterprises, so computers have the potential significantly to challenge and alter the ways knowledge is assessed and valued in education. Some studies have cited the rapid growth of the Maker Movement as evidence of such a change, calling for further research on its pedagogic approaches. For example, Papavalasopoulou, et al., (2017) recommend further research on the tools and technologies that facilitate maker learning such as Raspberry Pi. They also suggest further investigation on the analysis of ‘maker’ instruction in the classroom and studies that account for learning differentiation among age groups as a way of understanding the impact a decentralised, constructionist learning environment might have on learning.

CONCLUSION

Embracing and incorporating technology brings important opportunities for social and experiential learning, but doing so also requires thoughtful consideration of the impact on a number of foundational concepts. For instance, we must consider how technology affects the learning structures in our schools, the role and nature of assessment, the power dynamic between and among teachers and learners, the conceptualisation of what we mean when we describe the school ‘community,’ and the role of assignments and projects. This wide array of factors that must be reconsidered makes abundantly clear that the successful integration of technology cannot be achieved in a segregated or bolt-on way. Adding technology to the recipe of learning changes – and must change – the entire flavour of education.

As a means of scaffolding social and experiential learning and driving a learner-centric educational programme, the integration of technology calls for precisely the kind of reconsideration of the design, function, and purpose of education that we noted in the first chapter of this book. The complexity surrounding its integration presents both educational technology’s greatest challenge and its greatest potential benefit. It also underscores the reason technological integration is sometimes so partial or superficial, demonstrating little educational impact: schools and teachers may find themselves so overwhelmed by the scope of potential challenges that they respond by attempting to limit technology’s impact, relegating it to ‘nonthreatening’ uses. Such limited deployments – for example, using technology solely to streamline information delivery – are categorised in Puentadura’s SAMR model (2008) as ‘substitution.’ In such substitutionary uses, technology offers little by way of transformation, and its benefits, often recorded only by assessments and measurements tied to non-technological practices, may not be immediately apparent. And as we have seen, such narrow usage may also be behind some of the confusion demonstrated by research on educational technology.

However, by allowing technology to facilitate social and experiential learning, educators can begin to realise some of the benefits associated with Papert’s vision of technological empowerment. In these instances, learning is extended into new dimensions, providing learners with the opportunity to develop and solidify their knowledge and skills in ways that make them more robust and more broadly applicable. While technology is not the only answer, its appropriate use can make learning richer through constructionism, enabling learners to customise their learning experiences and reach into new contexts.

Over the past thirty years, the field of learning has presented a complex and evolving picture. Nearly every study, no matter its focus or results, can be qualified or countered by another study. As we have noted, many of these contradictions come from competing visions of what education is—or what it should be. Yet despite all of this complexity and contradiction, unambiguous patterns have begun to emerge:

- **Inadequately prepared or equipped teachers can impact learning negatively, regardless of the methodology or equipment provided in the learning environment.** Research has repeatedly demonstrated a clear connection between teacher preparation and the success of any learning method, even for learner-centric approaches;

- **Novice and less-experienced learners benefit from guided support or instruction,** although this guidance may come from peers or fellow learners as well as from teachers. While fully self-directed learning can be productive for some learners depending on their age and abilities, it can be difficult for some learners to move from inexperience to mastery without support from others;

- **Many learners benefit from designing the goals and assessments for their projects,** especially if the projects are associated with real-world situations or situations in which the learners are invested. Those who perceive goals and assessments as foreign tend to view projects more negatively, regardless of how well they perform on them. Learners often perceive projects as ‘boring’ or ‘irrelevant’ if projects are disconnected from their interests and developing abilities. Participating in designing goals and assessments offers many students a sense of investment;

- **Some learners are reticent to participate in the design of their own learning,** feeling unprepared or un incentivized to contribute. These learners may perceive self-directed learning as a distraction from the instructionist, examination-focused learning that characterizes much of modern education and may consider learner-centric activities to be less serious or less valid, unlikely to benefit them when it comes time for formal or standardized assessments;
Assessment can negatively impact the learning environment. Concern that assessment serves primarily administrative or bureaucratic purposes can rob learners of agency and alienate them from educational experiences. Assessment is not neutral; it not only measures, but shapes the learning environment, reifying what is measured and obscuring whatever remains outside of its scope. If we continue to measure the success of learning only by content-focused methodologies, for example, then only content-focused pedagogies will appear to be productive or successful. If we want to incorporate new or emerging methodologies with differing focuses, then we must develop new, parallel methods of assessing and qualifying that match those methodologies;

Holistic learning approaches must expand beyond information delivery to focus on building communities. Requiring individuals to build connections and leverage opportunities beyond the classroom’s walls helps them become more engaged in the learning process. Socially rich learning environments connect learners with a network of experts, practitioners and interested parties who can help them form a ‘community of practice’ that supports individual needs while also giving learners valuable partners. In time, participation in these communities can make students more confident about applying their knowledge in contexts beyond schools and about pursuing ongoing educational goals.

As we look to the future, further work needs to be undertaken to refine education and identify the precise path learning must follow. For now, we believe that the momentum behind making and constructionism and the congruence of constructionist approaches with the new technological tools available to teachers and learners of all kinds offers a clear indication of education’s future trajectory.

Constructionist methodologies offer important chances for learners to collaborate across disciplines, apply their learning in novel or even unanticipated contexts, and develop the adaptability and flexibility they will need to succeed in changing environments. These learning approaches are considerably more likely than instructionist pedagogies to help learners develop the essential ‘21st-century skills’ of innovation, creativity, entrepreneurship, and resilience. Finally, these approaches make irrelevant the question of whether education should focus on preparing learners for the workforce or offering them opportunities for self-realisation and self-fulfillment. By doing both at the same time, these emerging learning methodologies offer us a rare and important opportunity: the chance to harness the energy of a vast community of learners and to leverage the excitement inherent in their learning to solve real problems in the real world.
CONSTRUCTIONISM AND SOCIAL CONSTRUCTIONISM


Ackermann contrasts Piaget’s constructivism with Papert’s constructionism, exploring the contributions and omissions of each theoretical framework. She observes that “Piaget’s theory provides a solid framework for understanding children’s ways of doing and thinking at different levels of their development. It gives us a precious window into what children are generally interested in and capable of at different ages.” Piaget’s view of education has three foundational notions:

Teaching is always indirect, so learners interpret what they hear in the context of their existing knowledge and experience;
The ‘transmission’ model of human communication is inadequate. Knowledge is an experience that is acquired through interaction with the world, people, and things. Any theory that ignores resistance to learning does not provide a thorough framework. Learners who resist may be doing so because the new information is not yet compelling or clear enough to convince them to abandon their existing views. Viewing new learning as an external disruption can offer a compelling reason for restructuring and realigning learning opportunities.

Examining Papert’s contribution, she observes that constructionism helps us understand how ideas get formed and transformed when expressed through different media, when actualised in particular contexts, when worked out by individual minds. The emphasis shifts from universals to individual learners’ conversation with their own favorite representations, artifacts, or objects-to-think with.
Ackerman reminds readers that Papert’s constructionism does not view knowledge as a commodity to be transmitted, encoded, retained, or reapplied. Instead, it is constructed out of personal experience and is a function of relationships and connections built by individual learners. Understanding that knowledge is formed and transformed within specific contexts, shaped and expressed through different media, and processed individually in the mind of each learner yields a fundamentally different conception of learning and teaching. The highly personal nature of learning is also one of the motivations for Papert’s focus on the fragility, contextuality, and malleability of knowledge under construction.


The authors begin their analysis by highlighting what is ‘right’ with social constructionism and by outlining its core tenets. Although theorists do not universally agree about the extent to which it can be applied, most social constructionists believe that the world we experience and the identities we project are a product of social processes. For educators, this means that learning is an inherently social process which cannot be isolated or objectified. Second, most agree that social constructs are historically and culturally specific, varying and changing over both space and time. Further, not only can what we know be different—the product of a particular moment in history, a particular culture, or a combination of both—but the ways we conceptualise knowing can also differ, as can the elements we consider to be ‘proofs’ or ‘guarantees’ of our knowledge. From an educational perspective, this is one reason to seek culturally and contextually appropriate forms of validation rather than relying on standardised, one-size-fits-all methods. Third, most theorists believe that the questions we ask and the answers we obtain within a socially constructionist framework are fundamentally, profoundly, and directly related to the activities we carry out. Essentially, echoing Papert’s conceptualisation, social constructionists believe that knowledge is inextricably linked to—and emerges as a product of—activity and purpose. Finally, social constructionists emphasise the malleability of perceptions of the world, a characteristic that emerges from their constructedness. This suggests that learning should be understood less as a static product and more as a dynamic process. Learners continue to refine and reinterpret the world as their perceptions, their sociocultural identities, and their knowledge changes, and this means their conception of the world continues to change as well.

However, the writers feel that there are critical flaws in social constructionism that prevent it from giving a complete picture. Notably, they point to three issues which they believe social constructionism fails to consider adequately: embodiment, materiality, and power. As they see it, the most significant weakness of social constructionism involves its often exclusive emphasis on the role of language in conceptions of both
individuals and the world, leading practitioners to ignore these three pivotal factors. By presuming that language is a neutral, all-encompassing force, social constructionists fail to see the significant challenges that embodiment, materiality, and power pose to their perceptions. By definition, these include:

**Embodiment:** the influences of embodied factors, including personal/social histories, upon perceptions of social situations and individual activity;

**Materiality:** the possibilities and constraints inherent in the material world and the ways that they have always already shaped and informed the social constructions we live with;

**Power:** the inequalities that can be generated or perpetuated by institutions, governments, multinationals, and other power structures, including those categorised as “capitalist” or “patriarchal” that are based on a dialectic of superiority and inferiority.

Without accounting for the impact of these challenges, social constructionism can only describe part of the picture, and in so doing, creates a flawed or false narrative that can perpetuate problems and inequities.

Educators interested in social constructionism must consider the ways these three factors influence the design, conduct, and evaluation of learning experiences. Allowing a naïve construction that fails to account for these factors produces a learning methodology that does not serve learners as well as it could.


Galbin begins by exploring definitions of social constructionism, starting with the notion that “[t]he subjects that social constructionism is interested in are those to do with what anthropologists call culture, and sociologists call society: the shared social aspects of all that is psychological.” Social constructionism considers the constructed nature of these aspects, challenging our knowledge of ourselves and of the world. Regarding children, Galbin contends that, “the child functions in relation to its environment, constructing, modifying and interpreting the information s/he encounters in his/her relationship with the world.”

Galbin’s definition of social constructionism thus rejects fixed approaches to knowledge that are essentially non-reflexive. Instead, social constructionists argue that assumptions about the social world should be viewed critically, noting that these assumptions often serve to reinforce the interests of dominant social groups rather than offering a more comprehensive base of knowledge. Instead, how we understand the world should be seen as a product of historical processes involving interaction and negotiation between groups. The goal of research and scholarship, therefore, is not to produce knowledge that is fixed and universally valid, but to open up a dialogue about what has been constructed. Social constructionism also represents a
movement toward redefining psychological constructs such as the ‘mind,’ ‘self,’ and ‘emotion’ as socially constructed processes that are produced by social discourse.

Galbin also highlights the varieties of social constructionism, noting that there is no single social constructionist position and no single paradigm. The concept of what constructionism is often dependent on the author’s or critic’s aims. Within postmodern theory, for example, the concept of socially constructed reality stresses the ongoing construction of worldviews by individuals in dialectical interaction with society. Galbin concludes by arguing that social constructionism is “a way of thinking and doing that moves away from expertise-based, rational, hierarchical, and result-focused models going toward more participatory, co-creative, and process-centred ones.”


In this introductory chapter to *Constructionism*, Papert and Harel set the stage for this learning approach. They write, “the simplest definition of constructionism evokes the idea of learning-by-making,” pointing out that constructionism shares constructivism’s view of learning as “building knowledge structures” through progressive internalisation of actions. They argue that this should ideally happen in a context where the learner is consciously engaged in constructing a public persona; constructing for an audience and demonstrating that construction helps solidify the learning. For Papert and Harel, instructionism and constructionism represent fundamentally divergent strategies for education. As they argue, this “split goes beyond the acquisition of knowledge to touch on the nature of knowledge and the nature of knowing.”

Papert and Harel also comment on the introduction of technology in education, warning that there is a “tendency for ‘computer literacy’ to be conceptualised as adding new content material to a traditional curriculum.” Thus, instead of facilitating learning and the creation of knowledge, technology can be perceived simply—and erroneously—as an alternative tool to deliver content. Viewed this way, computer-aided instruction has the danger of “amplifying the rote and authoritarian character that many critics saw as manifestations of what is most characteristic of, and most wrong with, traditional school.” Instead, they contend that technology must empower the processes associated with constructionism. According to Papert and Harel, computers have the greatest impact on learning when they alter the nature of the learning process, shifting the focus from transfer of knowledge to students to production of knowledge by students.

**PROBLEM-BASED LEARNING**

The authors ground problem-based learning on constructivist assumptions about learning. They argue that it works, in part, because people continuously solve ill-structured problems (that is, problems with multiple or unknown goals) in daily life. In addition, since knowledge that is anchored in specific contexts is more meaningful, more integrated, better retained, and more transferable, learners derive meaning from deep interactions with the contexts in which they are working or learning. However, a genuine context is not necessarily required. The authors suggest that learning can also occur when students address simulations of an ill-structured problem.

To be effective, problem-based learning must be student-centred, self-directed, and self-reflective. For this reason, tutors should serve as facilitators rather than knowledge disseminators, supporting and facilitating the learning process. By serving as a resource rather than dominating students, tutors create an environment for inquiry and discovery.

The authors also discuss the research around problem-based learning, examining its impact on student learning outcomes, including knowledge acquisition and application, retention of content, problem-solving skills, higher order thinking, self-directed learning, and self-perception. In terms of short-term retention, research demonstrates either no difference or slightly less recollection by students in problem-based courses when compared to those in instructionist courses. However, in terms of deeper processing of information, students in problem-based courses demonstrated better retention of knowledge over a longer period of time. Research has also shown that problem-based learning classes improve learners problem-solving skills and higher order thinking abilities. Studies also provide strong evidence for the positive long-term effects of problem-based learning on students’ self-directed and life-long learning skills and attitudes, offering significant advantages by preparing students for real-world challenges.


Wilder defines problem-based learning as a learner-centric approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop viable solutions to a defined problem. For Wilder, problem-based learning must be driven by an authentic, ill-structured problem, which students work collaboratively to define and resolve. This allows them to develop and strengthen their communication, presentation, and critical-thinking skills. She stresses that problem-based learning is constructivist, activating learners’ prior knowledge so they can build meaningful connections between what they already know and what they are encountering as new knowledge.

Wilder examines several studies of problem-based learning’s efficacy for student achievement in secondary education, specifically seeking to understand whether
the problem-based approach results in higher academic achievement than more direct instructionist approaches. In her assessment of peer-reviewed studies she concluded that only seven demonstrated some form of advantage for problem-based approaches. While some studies showed evidence of higher achievement for students taught using a problem-based methodology compared to those experiencing more instructionist curricula, two of the studies revealed no significant difference in academic achievement between the two groups. In fact, one study revealed that the problem-based group scored significantly lower on a standardised test than the control group. However, this study focused on an atypical high school course (agriculture), and therefore may not be generalisable as proof that problem-based learning negatively impacts student achievement.

Wilder concludes that while research provides evidence of some positive impact for problem-based approaches, it is not possible to claim with a high degree of confidence that problem-based learning is the best way to increase content knowledge.

PROJECT-BASED LEARNING

Bell defines project-based learning as a student-driven, teacher-facilitated approach where learners pursue knowledge by asking questions that have piqued their curiosity. She argues that project-based learning is an effective approach for creating independent thinkers and developing 21st-century skills. As standardised testing does not adequately measure these skills, project-based learning also provides a more authentic form of assessment.

Bell provides evidence from several studies indicating that project-based learning is at least as effective as more instructionist teaching and assessment methods. However, project-based learning provides significant advantages in the development of skills. Students learn accountability through daily goal setting and through meeting the expectations of their peers. They also become more proficient in communication, negotiation, and collaboration. However, many of the skills learned via project-based methods are not measurable through standardised tests. Bell contends that a shift toward more authentic assessment is necessary to show the full picture.


Blumenfeld and her colleagues define project-based learning as a comprehensive perspective focused on teaching by engaging students in investigation, where students are able to pursue solutions to nontrivial problems. They do so by asking and refining
questions, debating ideas, making predictions, designing plans and/or experiments, collecting and analysing data, drawing conclusions, communicating their ideas and findings to others, asking new questions, and creating artefacts.

Proponents of project-based learning contend that as students investigate and seek resolutions to problems, they acquire an understanding of key principles and concepts. Project-based learning also places students in realistic, contextualised problem-solving environments. This emphasis can better connect the classroom to real-life experiences. Project-based learning also promotes links among subject disciplines and rather than a narrow view of knowledge, presents an expanded view.

The authors expand upon the factors that may affect students' perceived and actual competence as they engage in complex projects. First, students must have sufficient knowledge of the content area and specific skills to explore information that is pertinent to the problem. Second, students need to be proficient in skills to generate plans, systematically making and testing predictions, interpreting evidence in light of those predictions, and determining solutions. As they work, they monitor progress toward their goals, assembling units of information into larger schemata, rehearsing newly consolidated learning, and translating information from one form or representation to another.

The chief task of teachers in a project-based course is to create opportunities for learning by providing access to information. Moreover, they must create an environment conducive to constructive inquiry. They support learning by scaffolding instruction and modelling and guiding students to make tasks more manageable. Teachers also assess progress, diagnose problems, provide feedback, and evaluate overall results. For project-based learning instruction to be successful, teachers should help students become aware of and examine their own conceptions and move toward the development of mastery.

**MAKING AND MAKER SPACES**


In this article, Dale Dougherty, considered by many to be the founder of the ‘maker movement,’ defines the characteristics of ‘making’ and describes the reasons he sees behind its growing popularity. Dougherty believes that “The maker movement has come about in part because of people’s need to engage passionately with objects in ways that make them more than just consumers.” He also acknowledges the importance of technology and digital tools in ‘making.’ According to Dougherty, when people make something, the objects they create demonstrate what they have learned to do, and this provides evidence of learning.

Dougherty bases his apology for maker learning’s effectiveness on Dewey’s ideas about the benefits of learning by doing, as well as on research that proves that learning happens best with tactile engagement. To spread the educational adoption of
maker learning, he recommends engaging teachers who are already involved in some form of ‘making’ outside of school. These teachers already understand the relevance and importance of making and have experience that enables them to serve as mentors for their students.


In this article, the authors describe the emerging role of the maker movement in education. The authors initially define the maker movement as, “the growing number of people who are engaged in the creative production of artifacts in their daily lives and who find physical and digital forums to share their processes and products with others.” They then highlighting the link between Papert’s constructionism and the maker movement, arguing that “learning through making reaches across the divide between formal and informal learning, pushing us to think more expansively about where and how learning happens.”

The influence of the maker movement can be seen across a broad range of spaces in the context of education. In higher education, so-called ‘Fab Labs’ represent an example of individuals working at the intersection of the digital and the physical, using digital tools to design products and artefacts that can then be built. This formal use of making parallels the making one finds in informal learning environments such as public libraries, museums, and independent non-profits. Yet informal maker spaces such as these have also expanded the range of projects considered to be appropriate, extending from books to wearable electronics. This expansion has also extended the definition of what constitutes a ‘maker.’ Stretching across the formal/informal instructional divide, the maker movement thus “democratize[s] access to the discourses of power that accompany becoming a producer of artifacts, especially when those artifacts use twenty-first-century technologies.”

Halverson and Sheridan highlight three components of the maker movement that must be considered when framing research questions and formulating policy:

- **Making as a set of activities** that can be designed with a variety of learning goals in mind
- **Makerspaces as communities of practice** constructed in a physical place and set aside for a group of people to use as a core part of their practice
- **Makers as identities of participation** that people adopt within the maker movement.

Making forces us to reevaluate how we learn, what we learn, and how we assess the importance of what we’re learning. As Halverson and Sheridan write:

> “With this work, we propose to change the conversation from being about the design of schooling as informing learning to, instead, the design for learning as informing schooling. Bringing the maker movement into the education conversation has the potential to transform how we understand “what counts” as learning, as a learner, and as a learning environment.”

The purpose of this article is to introduce making and the maker movement to engineering researchers and teachers, emphasising its promise to bring playful, rich engineering and design activities into primary and secondary education. In this overview, Martin first describes three elements of making and the maker movement that are critical for understanding its educational value: 1) digital tools, including rapid prototyping tools and low cost microcontroller platforms, that characterize many maker projects, 2) community infrastructure, including online resources and in-person spaces and events, and 3) the maker mindset: values, beliefs, and dispositions that are commonplace within the community. Martin argues that there is no consensus about the definition of making, and draws from Sheridan, Honey, and Kanter, among others, to develop a working definition of making as

a class of activities focused on designing, building, modifying, and/or repurposing material objects, for playful or useful ends, oriented toward making a “product” of some sort that can be used, interacted with, or demonstrated.

Martin then discusses the three key resources necessary for making. The first is technology, and Martin outlines two classes of tools that are the most prominent: digital physical tools and digital logic tools. Digital physical tools (also known as ‘digital manufacturing tools’) shape materials or material objects into new forms. Examples of such tools include 3D printers, laser cutters, and digital embroidery machines. The second class of digital tools involves low-cost, hobbyist-friendly microcontrollers like Arduino, BeagleBone, and Raspberry Pi (this category also includes mini-computers and other electronics) that allow makers to create digital objects and code.

The next resource is the community that has arisen around making, and this human resource is just as important as the tools. The communal infrastructure surrounding making includes person-to-person meetings that can take place at museums, maker spaces, and events like Maker Faire, as well as in online settings such as social networks and maker-oriented websites.

The final essential aspect of the maker movement is the actions – the making – that establishes one as a true participant. Without an action-based demonstration of the values and dispositions that typify the community of makers, one cannot be said to be part of the maker community.

According to Martin, the maker movement manifests four essential characteristics that make it valuable for education:

**It is playful:** Play, fun, and engagement are at the heart of making. Research has demonstrated that play is a fundamental developmental activity for children and adolescents. A playful learning environment encourages experimentation and experience with change and variability;
It is asset- and growth-oriented: The maker movement often focuses on skills rather than abilities. The developmental nature of making aligns well with the concept of ‘growth mindset’ and with asset-based views of youth;

It is failure positive: Within the maker mindset, failure is celebrated, as it is understood to be a pathway to learning. Failure is not something to be feared or avoided, but is instead seen as a motivator, driving iteration and development;

It is collaborative: The maker movement embraces sharing and collaboration. Participants are encouraged to share ideas and projects, using their skills and abilities at whatever level to help others.

Martin concludes this summary by outlining seven reasons why making is a valuable learning activity: 1) it aligns with the curricular demands of schooling, particularly in engineering practices; 2) it gives youth access to sophisticated tools for building and thinking; 3) it involves creating things, seeing how they perform, and sharing them with others; 4) it is playful and highly tolerant of errors; 5) it advocates for a ‘growth mindset,’ where, given effort and resources, anyone can learn the skills needed to complete any project; 6) maker environments typically give youth substantial say in what and how they make; and 7) making occurs within linked learning communities, spanning in-person and online contexts, and involving people of various ages, backgrounds, and levels of knowledge.


Sheridan and her colleagues define maker spaces as “informal sites for creative production in art, science, and engineering where people of all ages blend digital and physical technologies to explore ideas, learn technical skills, and create new products.” They ground making and maker spaces firmly in Piaget’s theory, reminding readers that “the centrality of developing an idea and then designing and creating an external representation of that idea is a core tenet of constructionism,” regardless of whether that representation exists in physical or digital form.

Incorporating a maker space encourages more holistic thinking, which is an important advantage according to the authors. In order to construct a project that meets their goals, learners must use a range of knowledge and experience in a way that typically breaks down established disciplinary boundaries. This cross-disciplinary approach, in turn, leads to innovative work with a range of tools, materials, and processes.

Sheridan and her colleagues also compare the features of three different maker spaces, describing how participants learn and develop through the complex design and making practices they employ. In all of these spaces, regardless of the context, ‘making’ involves discovering problems and projects to work on; utilising diverse tools, materials, and processes; iterating through designs; becoming a member of a broader
community; taking on leadership and teaching roles as needed; and sharing creations and skills with the wider world.

www.pdfs.semanticscholar.org/fa5b/4e88c78f380b4727d445afa33bea5212a21d.pdf

In this article, the authors argue that the current conceptualisation of the maker movement, if left unquestioned, could restrict educational experiences for working-class students and students of colour. The authors contend that

In its most narrow, branded version, making is depicted as a uniquely American activity focused on technological forms of innovation that advance hands-on learning and contribute to the growth of the economy [...]. The historical forms of making [...] are grounded in gendered, white, middle-class cultural practices.

The authors also argue that there is a strong economic discourse in making, contributing to the potential exclusion of underprivileged students. They contend that making is often considered to be a “middle-class movement” and an “adult white, middle-class pursuit” that is shaped by leisure time and economic resources.

However, a reconceptualisation of making could lead to greater inclusion.

the ways making and equity are conceptualised can either restrict or expand the possibility that this movement will contribute to intellectually generative and liberatory pedagogical practices for working-class students and students of colour.

Particularly within education, the maker movement has not always represented a step toward equity. The authors provide a brief analysis of educational injustice in order to frame how such injustices might re-emerge within making environments. They then provide a historicized approach to making as a cross-cultural activity to demonstrate how equity can be placed at the centre of the maker movement, paying attention to pedagogy and to the socio-political values and functions of making. They conclude by arguing that pedagogical designs that take into consideration the concepts of equity “will be more responsive to the histories, needs, and experiences of working-class students and students of colour.”

**LEARNER-CENTRED LEARNING**


This brief summary of Weimer’s 2002 *Learner-Centered Teaching: Five Key Changes to Practice* outlines important rationales for instituting a learner-centric approach.
First, Weimer notes that “learner-centred teaching engages students in the hard, messy work of learning.” Because of the structure established in a learner-centric environment, learners must engage and take responsibility for their learning rather than passively absorbing and repeating information. Second, these approaches help learners develop essential skills including critical thinking, problem-solving, evaluation of evidence, argument analysis, and hypothesis generation. Third, learner-centric approaches encourage learners to reflect on what they are learning and how they are learning it. Fourth, these approaches motivate learners because the learners become custodians of their own learning processes, taking control of their educational journeys. Finally, learner-centred teaching encourages student collaboration and the development of interpersonal skills.

Weimer’s research demonstrates the benefits of learner-centred teaching, including meaningful and long-term understanding of what has been learned; independent, lifelong learning; increased motivation to learn; and improved outcomes, especially with conceptual understanding assessments. She warns that while learner-centred teaching is often more effective than instructionist, teacher-centred approaches, the benefits are not necessarily automatic or immediately apparent. In part, despite the various benefits, this friction can cause resistance from students and teachers in implementing learner-centred pedagogies.


Building on his work about communities of practice, Wenger-Trayner here develops a theory of multi-scale learning systems to provide a broad portrait of learning today. He develops a theoretical foundation to address the learning challenges of our globalised world. What trends can we observe and what do these trends suggest for practitioners in business, education, government, and non-profits? Wenger-Trayner argues that we must pursue learning theories intended to impact many kinds of researchers and practitioners: executives, government officials, policy-makers, educators, community leaders and social workers. This diverse group, in turn, must rethink how social institutions contribute to our overall learning capability. From an educational perspective, Wenger-Trayner’s project aims to allow reflection on the role of education in a learning society, on the learning needs of students, and on the relationships between institutions and broader social learning systems. This project is framed within the theoretical convergence of learning theory and social theory that Wenger-Trayner laid out with his research on communities of practice. He explains:

The scope of the project is broad. It looks at learning as a social process that does not know national, sectoral, or disciplinary boundaries. The idea is that a learning theory for our times must be able to talk about the world itself as a global learning system in which our individual learning takes place. It cannot be confined by the traditional divisions among education, business, government, non-profit, and civic
domains. Nor can it assume that learning is confined to specific settings or moments in people’s lives. Learning is a property of social systems at various levels of scale. It is also the driving force of lifelong trajectories that we build in the context of these social systems […]. The project seeks to create a vision of learning, of what is required, of what is possible.

Wenger-Trayner argues that we must focusing on ‘meaningfulness’ because this is the level at which learning becomes part of the human experience. He concludes that bringing learning and social theory together is useful to both perspectives. “Learning theory gains the ability to focus on the production of meaningfulness, not just the mechanics of skill acquisition […] by locating learning within our engagement with social systems that provide tools and context for negotiating meaning.”

He focuses on four learning trends that characterise modern learning: 1) the ‘horizontalization’ of learning, by which he means the shift away from a vertically hierarchical relationship between producer/teacher and recipient/learner; 2) the ‘partialization’ of learning imperatives, by which he means the shift toward learning to participate productively within a community rather than seeking to master everything oneself; 3) the personalization of value creation, which describes the need for personal engagement in work; and 4) the individualization of ‘trajectories of identity,’ which describes how people use expertise and skills to craft identity. He concludes by placing the need for a new learning theory in the context of globalisation which requires learning to be conceptualised both globally and locally.


This paper uses the framework set out in Maryellen Weimer’s *Learner-Centered Teaching* to discuss several important aspects of learner-centred education. Although the case studies involve higher education, many of Wright’s points are also relevant for the K–12 context. Wright addresses the desire of many instructionist teachers to ‘cover’ the content of the course. This has led to a “neglect of ensuring that the course objectives are being met, and erroneously equating a good course with a rigorous course, rather than a course in which students learn.” An emphasis on course content – sometimes in unmanageable amounts – often forces learners to resort to memorisation rather than conceptualisation and internalisation. This redefinition around content also changes the definition of what many teachers mean when they describe someone as a ‘good’ student. In a content-focused context, learners who have mastered informational reproduction are said to be ‘better’ performers, regardless of whether they have developed core skills, internalised the ability to apply knowledge, or grown the resources and perspectives to continue learning.

Since the definition of learner success is linked to the way teachers define the central focus of learning, Wright argues that the conceptualisation of teachers’ roles
must also change in learner-centred classrooms. Instead of instructors perceiving themselves as the primary arbiters of content, learner-centred instructors favour a more ‘democratic’ and collaborative approach, empowering students to be active participants in their learning. In learner-centred classrooms, the responsibility for learning – including intellectual exploration and pursuit and the structuring of learning – shifts to the learners, allowing them to direct their learning rather than being passive recipients of information.

According to Wright, the purpose of evaluation in learner-centred classrooms is not to generate grades but to promote and trace learning. When the shift is made from teacher- to learner-centred education, assessment moves from focusing on the repetition of content to the demonstration of learning skills, objectives, and goals. Additionally, assessment becomes the learners’ domain rather than falling within the exclusive purview of teachers. Learners are taught to assess their own work and the work of their peers. Assessment gives learners yet another opportunity to practice and perform the theoretical and practical skills they are developing.

**SOCIAL LEARNING THEORY**


Bandura asserts that new patterns of behaviour can be acquired through direct experience or by observing the behaviour of others. Social learning theory assumes that modelling influences learning through informative functions. Bandura believed that four conditions are necessary for effective modelling that would lead to learning:

**Attentional processes:** People cannot learn much by observation if they do not attend to or fail to recognise the essential features of the model’s behaviour;

**Retention processes:** People cannot be influenced by observation of a model’s behaviour if they have no memory of that behaviour. The long-term retention of modeled activities is a second essential factor.

**Reproduction processes:** To achieve behavioural reproduction, learners must reproduce a set of responses that are congruent with the modelled patterns. The amount of observational learning people can reproduce behaviourally depends on whether or not they have acquired the component skills in a way that allows their easy integration to produce new patterns of behaviour. However, if the response components are lacking, behavioural reproduction will be faulty.

**Reinforcement and motivational processes:** People can acquire, retain, and possess the capabilities for skilful execution of modelled behaviour, but if that behaviour is negatively sanctioned or unfavourably received, learners may resist demonstrating or be unable to demonstrate their learning. When positive incentives are provided, observational lessons which were previously unexpressed may be translated into action.

This chapter provides a comprehensive introduction to and interpretation of Vygotsky’s concept of ‘zones of proximal development.’ Chaiklin locates Vygotsky’s groundbreaking work in the fields of developmental and educational psychology by highlighting three basic features of Vygotsky’s model. The first focuses on the idea that while people are able to perform a certain number of tasks alone, they can perform a greater number collaboratively. The second examines the interactions between a child and the adult, teacher, or ‘more competent’ person who serves as a mentor, extending the learner’s ‘zone.’ The third focuses on ‘properties of the learner,’ including notions of a learner’s potential and readiness to learn. Chaiklin’s goal here is to prompt greater understanding of the nature and implications of Vygotsky’s notion.

Vygotsky’s conception is built on a few foundational notions. First, it considers the child as a complete entity comprised of thoughts, experiences, capabilities, and desires. Perceiving the child holistically as a conglomeration of these psychological functions enables us to trace learning or development as a qualitative change in the structural relationships between them. Vygotsky argues that this change is brought about by the child’s social engagement with others. Learning begins with the child’s perception and interests at a particular age or stage of development, but it is exposure to the thoughts, experiences, and capabilities of others that leads to learning. Witnessing the gap between a child’s current status and the status of a more experienced adult or mentor – which is the definition of the ‘zone of proximal development’ – leads the child to develop new functions and abilities. The ‘zone of proximal development’ thus refers to both the functions that are developing for a given age period (which are ‘objective’), and a child’s current state of development in relation to the functions that need to be realised (which are ‘subjective’).

Chaiklin concludes by addressing how one might identify or assess a child’s ‘zone of proximal development.’ As Vygotsky’s work only presents a general theoretical logic for measuring this zone, Chaiklin argues that it should be defined on the basis of an explanatory account of the nature of the child’s development. In his opinion, all assessment should therefore be directed toward understanding and defining the child’s current developmental trajectory.


This paper discusses the instructional strategy of cooperative learning within the framework of Vygotsky’s ‘zone of proximal development.’ The author uses Vygotsky’s concept to provide a conceptual basis for identifying five elements of cooperative
Annotated Bibliography

Doolittle points to the gap between a person's existing abilities and the abilities of those with whom and from whom they learn (the ‘zone of proximal development’) as central to Vygotsky’s theory of cognitive development. Vygotsky believed that the social interaction between those who are less experienced and those who are more experienced is an essential component of learning, and it is thus the origin of all cognitive development.

Doolittle uses the ‘zone of proximal development’ to analyse each of the five elements of cooperative learning: positive interdependence, face-to-face interaction, individual accountability, small-group and interpersonal skills, and group self-evaluation. This forms the basis for nine core suggestions about the use of cooperative learning. Doolittle believes teachers should teach using whole and authentic activities, create a need for what is to be learned, and utilise activities or exercises that require social interaction. He also suggests that teachers should provide opportunities for verbal interaction, monitor student progress, provide instruction that precedes a student’s development, and use instructional scaffolding. Finally, he suggests that teachers should provide opportunities for students to demonstrate their learning independent of others and construct activities that are designed to stimulate both behavioural changes and cognitive/metacognitive changes. Doolittle contends that these nine suggestions can be applied to numerous cooperative learning activities in any classroom.


This interview with Étienne Wenger-Trayner examines his concept of ‘communities of practice’ with the aim of contributing to the understanding and use of this theory. In the interview, Wenger-Trayner explains how he conceptualises identity and participation in order to develop a social theory of learning in which power and boundaries are inherent. The article is thematically divided, presenting a holistic understanding of the key concepts of Wenger-Trayner’s theory from an educational perspective. Central to this is the notion that communities of practice can arise in any domain of human endeavour. Learning takes place through participation in multiple social practices and practices are formed through pursuing any kind of enterprise over time. Wenger-Trayner argues that his concept does not necessarily refer to a ‘group’ of people but to “a social process of negotiating competence in a domain over time.” The fact that this process can structure social relationships among the people involved is a secondary phenomenon. He contends that shaping identity is a central component of learning. In an educational setting, this implies that knowledge and identity are inherently intertwined. Knowledge cannot be disseminated without inviting individuals into an
identity in which this knowledge plays a meaningful role. Wenger-Trayner distinguishes between three modes of identification: imagination, engagement, and alignment, suggesting these are “different components of how we locate and orient ourselves in the landscape of practice in terms of our identity.”


In this article, Smith reviews the research by Jean Lavé and Etienne Wenger-Trayner on ‘communities of practice.’ Smith contends that these communities are everywhere and that most people are involved in a number of these self-organising systems at once. ‘Communities of practice’ can play an especially productive role in informal educational settings, so understanding how “learning [happens] within communities of practice, and how knowledge is generated allows educators to think a little differently about the groups, networks, and associations with which they are involved.” Within ‘communities of practice,’ learning begins at the periphery; as learners become more competent, they move toward the centre of the community, moving from observation to full participation. In this conceptualisation, learning is not seen as the acquisition of knowledge but as a process of social participation. Smith believes that these concepts provide significant guidelines for establishing productive learning: learning is generated by relationships between people; knowledge and activity are intimately interconnected; and educators and mentors must work to ensure that people can move from observation toward full participation in the community.


Vygotsky’s book is divided into two main sections. In the first part, he outlines the role played by language and symbolic thought in shaping higher psychological functions. In the second, he introduces the concept of the ‘zone of proximal development (ZPD).’

In the first part of his book, Vygotsky argues that children’s language is a tool that “they use in the solution of difficult tasks, to overcome impulsive action, to plan a solution to a problem prior to its execution, and to master their own behaviour.” He argues that these cognitive and communicative uses of language as a tool to structure experiences is what distinguishes people from animals. Vygotsky saw a link between language and perception in children, even at very early stages of development, contending that language plays a vital role in shaping our experience. He believed that the speech development of children and their use of language as a tool for mediating and structuring experience “clearly reveals the social origin of signs as well as their crucial role in the individual’s development.” In other words, Vygotsky saw all signs as ‘constructed,’ built to serve specific social and individual purposes.
Vygotsky's exploration of the interplay between language and perception led to his critique of contemporary research about the development of psychological processes. To overcome what he saw as the inadequacies of existing theories, which tended to focus on the products of psychological development, Vygotsky introduced three principles on which to base an analysis of higher psychological functions: 1) one must analyse processes, not objects, leading to an understanding of the process of psychological development; 2) one must seek explanation rather than description, digging behind apparently similar manifestations to discover the processes that lay beneath; and 3) one must account for what Vygotsky termed ‘fossilized behaviour,’ activities conducted automatically which might obscure the processes by which psychological development occurs.

Having set the stage by describing psychological development as a product of the interaction between constructed signs and experience, Vygotsky next introduces his concept of the ‘zone of proximal development.’ He defines the initial or ‘actual’ developmental level as “the level of development of a child’s mental functions that has been established as a result of certain already completed developmental cycles.” The ‘zone of proximal development’ consists of “the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers.” The space between these two developmental levels provides both an opportunity and a reason for growth, as a child is able to see and experience the new level of development manifested by the guide. This experience scaffolds an extension of the child’s capabilities, establishing a new developmental level, which, in turn, can be further extended through new interactions with adults or more capable peers.

Desire – the ability to view and experience developmental levels beyond one’s current level of ‘actual’ development – thus plays an important role in learning, but formal learning environments are not the only contexts in which desire may be sparked. For Vygotsky, play serves an equally important role in children’s development. In play, children create an imaginary situation in which new desires and new identities can be explored and experienced. In play, the game and its rules generate a new ‘horizon,’ creating a ‘zone of proximal development’ comparable to that created by guides in a more formal learning context. Further, in play, children can construct a fictitious ‘I,’ allowing them to experiment with different roles and imagine new possibilities for themselves.

For Vygotsky, all of this comes together in the movement from gestural to written language. At the first developmental stage, even before language, children communicate via gestures. As he writes, gestures are “the initial visual sign that contains the child’s future writing.” As children develop, games begin to link gestures to oral and then written language, with children constructing increasingly complex symbolic systems as they are led by adults and peers in play. For Vygotsky, “children’s symbolic play can be understood as a very complex system of ‘speech’ through gestures that communicate and indicate the meaning of playthings.” Early play gives way to drawing,
which is “graphic speech that arises on the basis of verbal speech.” This, in turn, is followed by the even more complex symbolic system of written speech. Thus, while the “understanding of written language is first effected through spoken language, [...] gradually this path is curtailed and spoken language disappears as the intermediate link.”

As an aside, extrapolating from Vygotsky’s three recommendations for teaching writing can offer a helpful model for all teaching. He contends that 1) writing should be taught in the preschool years; 2) children should be encouraged to see writing as necessary and meaningful by incorporating it into tasks necessary and relevant for life; and 3) writing should be taught naturally. Starting learners out in the study of a topic, a discipline, or a skill as early as possible – even before they have the necessary abilities, providing them with real-world and meaningful contexts, and teaching them naturally offers an excellent opportunity for engaging and extending their ‘zones of proximal development,’ resulting in significant growth and learning.


In this introduction, Wenger-Trayner defines ‘communities of practice’ as “groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly.” Three crucial characteristics define a ‘community of practice’:

the domain: a community of practice is defined by a shared domain of interest in which members learn from one another;

the community: community members build relationships that enable them to learn from and teach one another, involving joint activities and discussions, assistance, and the sharing of information and discoveries;

the practice: members of a community are practitioners, developing a shared repertoire of resources that include experiences, stories, tools, and ways of addressing recurring problems.

‘Communities of practice’ can provide benefits to a range of contexts and applications including businesses, design organisations, governments, educational institutions and organisations, professional associations, development projects, and civic life.


This paper addresses the prevalence of ‘communities of practice’ in society. Wenger-Trayner argues that everyone belongs to some community of practice — at work, at school, at home, in hobbies — suggesting that members are informally bound by what they do together and by what they have learned through their mutual engagement in these activities. Wenger-Trayner defines ‘communities of practice’ along three dimensions: the community’s focus, how it functions, and what it produces. Communities of practice can exist in any type of organisation because membership is based on
participation rather than on some sort of official status. These communities empha-
sise and organise themselves around the learning that people do together rather than
around an administrative unit to which they report, a project on which members are
working, or the outside experts and resources community members know. In these
communities, knowledge is created, shared, organised, revised, and passed on among
members, serving as the chief currency by which members establish and maintain
their association with the group. Wenger-Trayner concludes by pointing out that the
interactions with others that take place at the boundaries of a ‘community of practice’
are just as essential as the knowledge that members develop and exchange. The abil-
ity of a community to enable what Wenger-Trayner calls ‘legitimate peripheral partici-
pation’—the opportunity to move from being an outsider or observer to being a central
participant in the community—is essential for a community’s growth and sustainability.

EXPERIENTIAL LEARNING


In this chapter, Kolb outlines his theory of experiential learning. In his construction,
experiential learning provides a holistic, integrative perspective on learning that com-
bines experience, cognition, and behaviour. In Kolb’s model, learning is defined as a
process where concepts are derived from and continuously modified by experience.

Kolb delineates three models of experiential learning. The first is based on the
Lewinian model. This model emphasizes immediate personal experience as the focal
point of learning, giving life, texture, and subjective personal meaning to abstract con-
cepts. At the same time, experience provides a concrete, publicly shared reference point
for testing the implications and validity of ideas created in the learning process. The sec-
ond is based on the Dewey model. This second form emphasizes the developmental na-
ture of learning, where experiential learning consists of the transformation of impulses,
feelings, and desires into higher-order, purposeful action. The final form is based on the
Piaget model. In this model, experiential learning—as both a process and a product—is
understood to continue through to adulthood. This model suggests that development
takes place in a cycle of interaction between individuals and their environments.

Kolb concludes by outlining the characteristics of experiential learning.
Learning is best defined as a process rather than a product or outcome;
Learning is a process that must be continuously grounded in experience;
Learning requires the resolution of conflicts between dialectally opposed modes,
pursuing congruence through continual adaptation and refinement;
Learning is a holistic process of ongoing adaptation to the world involving the
whole person;
Learning involves interactions and exchanges between the person and the environment;
Learning is the process of constructing knowledge.

In this essay Vygotsky discusses the role of play in development. He positions play as vital to preschool children's development, but questions whether play is the predominant activity or simply the most frequently encountered form of interaction among preschool children. Vygotsky argues that play has a huge influence on a child's development because it represents the imaginary, illusory realisation of unrealisable desires. He contends that when playing,

a child is always above his average age, above his daily behaviour, in play it is as though he were a head taller than himself. [...] Play contains all developmental tendencies in a condensed form; in play it is as though the child were trying to jump above the level of his normal behaviour.

COMPUTERS AND CODING


The increasing importance for children to be computer literate has meant that computers have become increasingly prevalent in schools. This study assesses the effects of learning computer programming in LOGO on children's cognitive style (especially in terms of their reflectivity and divergent thinking), metacognitive ability, cognitive development (including operational competence and general cognitive measures), and ability to describe directions. This study found a marked difference in children's ability to produce original and creative ideas between those children exposed to LOGO and those who were not. The group exposed to LOGO outperformed the control group in both creative ideation and in metacognition tasks. However, the study determined that while programming may affect cognitive style, there is no evidence that it affects general cognitive development.


Papert's pioneering work examines how access to computers can affect children's thinking and learning. According to Papert, computers can contribute to children's mental processes and influence how they think, even when the children are not in physical contact with a computer. As he writes in his introduction,

This book is about how computers can be carriers of powerful ideas and of the seeds of cultural change, how they can help people form new relationships with knowledge that cut across the traditional lines separating humanities from sciences and knowledge of the self from both of these. It is about using computers
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...to challenge current beliefs about who can understand what and at what age. It is about using computers to question standard assumptions in developmental psychology and in the psychology of aptitudes and attitudes. It is about whether personal computers and the cultures in which they are used will continue to be the creatures of “engineers” alone or whether we can construct intellectual environments in which people who today think of themselves as “humanists” will feel part of, not alienated from, the process of constructing computational cultures.

For many, ‘computer-aided instruction’ implies that the computer teaches the child, or that “the computer is being used to program the child,” yet Papert contends that instead, the child should program the computer. In Mindstorms, Papert argues that it is possible to design computers in such a way that learning to communicate with them is a natural process. Further, he suggests that learning to communicate with computers could change the way other learning takes place as well.

Since computers have the potential to change not only how we teach, but also what we teach, Papert believed they should form an integral part of the educational environment. Just as access to personal computers has allowed individuals increasing levels of control and informational access, so educational access to computers could allow individuals to take increasing control over their own learning. In so doing, Papert believed learners would discover and create connections hitherto impossible in a non-technological learning environment.

For example, Papert argued that the teaching of mathematics (like the teaching of science) must shift from being intellectually isolated and dissociative to becoming more humanistic and connected. In Papert’s view, computers could assist productively with this project. Rather than displacing the human with the technological, computers could be used to unite humanistic and mathematical/scientific cultures. Papert attempted to empower such a unification through the development of Turtle Geometry, a programming language that allowed children to explore coding, learn geometry, and create art, all at the same time. By making Turtle Geometry approachable even for very young children, Papert believed ‘the turtle’ could serve as the first representation of formal mathematics for children. Once they had begun to see the relationship between their code and the designs it produced—in other words, once they had begun to think computationally—children could then move on to exploring ever more complex ideas and relationships. For example, they could begin to experiment and play with Dynaturtles, a turtle entity with ‘gravity’ that could help illustrate the basic principles of Newtonian physics.

Papert’s emphasis on learning by making and his erasure of the difference between ‘intellectual’ and ‘physical’ or ‘practical’ skills contrasts with the way many schools conceive of education. While schools have traditionally treated physical and practical skills (such as those gained in a ‘shop’ or ‘home economics’ class) as ‘non-intellectual,’ Papert saw important connections between the development of these skills and the development of a scientific theory. In both cases, learners must experience
and understand basic information, must put their knowledge into action, and must refine their ideas and approaches based on the results of their efforts. Papert therefore rejected the false dichotomy of ‘facts’ versus ‘skills,’ arguing that learning cannot be reduced to either term. In the context of using a computer to understand scientific principles, Papert believed that scientific knowledge is more akin to knowing a person, than it is to either knowing a fact or having a skill. In this way, children’s thinking – guided by play as a way of getting acquainted with the ‘character’ of science – has more in common with ‘real science’ than with ‘school science.’

Unfortunately, although Papert recognised that computers could be a useful tool for eliminating such false distinctions, he recognised that computers are typically used in schools to reinforce reductionist and fragmentary disciplinarity. In the same way that ‘school math’ and ‘school science’ are conceived as artificially isolated subjects divorced from real-world application, so ‘school computing’– far from being an empowering technology that offers learners increased agency and an ability to make new connections – too often becomes yet another isolated school discipline subjected to the standard school structures of instructionism and testing.

Spurred by what he believed to be the error of such models, Papert looked to Piaget in developing a new learning theory that could offer more productive educational opportunities. His ‘constructionism’ sought to bring knowledge and experience together in the making of objects as a means of ‘thinking through’ and testing a learner’s developing understanding. However, despite offering a compelling vision of the new ‘Learning Society’ that could emerge from this model, Papert recognised that the chief difficulty in establishing a new learning model would not be economic or technical, but social, overcoming established notions of what learning and education are. As he observes:

The computer by itself cannot change the existing institutional assumptions that separate scientist from educator, technologist from humanist. Nor can computers change assumptions about whether science for the people is a matter of packaging and delivery or a proper area of serious research. To do any of these things will require deliberate action of a kind that could, in principle, have happened in the past, before computers existed. But it did not happen.

Papert’s chief goal in Mindstorms is to offer a model that finally realises this vision, breaking down the artificial barriers that have characterised education for far too long.

**INSTRUCTIONIST PEDAGOGIES**


Based on current knowledge of human cognitive architecture, this article proposes that learner-centric models offering minimal guidance are ineffective for learning. Instead,
the authors contend that pedagogies based on direct instruction have greater impact on knowledge retention and academic achievement. They define direct instructional guidance as any pedagogical practice that fully explains the concepts and procedures students are required to learn, and they also include learning strategies that support this model of instruction. This stands in contrast with problem-based learning, inquiry and constructivist learning, and experiential learning, which they identify as minimally guided approaches.

Kirschner and his colleagues argue that since learners of all ages know how to construct knowledge when given adequate information, there is no evidence that presenting them with partial information enhances their ability to construct a representation more than giving them full information. Actually, quite the reverse seems most often to be true. Learners must construct a mental representation or schema irrespective of whether they are given complete or partial information. Complete information will result in a more accurate representation that is also more easily acquired.

In order to establish a research-based case against self-directed learning methodologies, the authors review a series of empirical studies. They note strong evidence from well-designed, controlled experimental studies that supports direct instructional guidance. For example, they cite research that demonstrates that when students learn science in classrooms with pure-discovery methods and minimal feedback, they often become lost and frustrated, and their confusion can lead to misconceptions.

The authors conclude that there is no substantive research to support the value of minimally guided instruction in the classroom. Instead, they believe that evidence almost uniformly supports direct, strong instructional guidance, rather than constructivist-based minimal guidance during the instruction of novice to intermediate learners. Even for students with considerable prior knowledge, strong guidance while learning is most often found to be equally effective as unguided approaches. Not only is unguided instruction normally less effective; there is also evidence that it may have negative results when students acquire misconceptions or incomplete or disorganised knowledge.