EDUCATION, LEARNING, AND KNOWLEDGE
a review of research and theory about constructionism and making
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IT IS THE perennial question: should education prepare individuals to enter the workforce, or should it be focused on social, academic, cultural, and intellectual development so the learner can become an engaged citizen? Should it focus on subject and content knowledge or the self-realisation of the individual, who learns for the excitement and reward of learning rather than learning in order to pass a test? In the world of the Fourth Industrial Revolution, characterised by increasingly complex and multivalent social and cultural connections, perhaps both of these questions require reevaluation. 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 (and precontextualised) information repeatedly through a series of formulas, ‘recipes,’ and standardised procedures. Such training was once considered essential for people who would enter 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 Economic Forum, the OECD, and a range of think tanks and international organisations have declared that education is ill-equipped to prepare learners for the jobs of the future, characterised by a need to collaborate across disciplines, apply knowledge in novel or unanticipated ways, and maintain flexibility, training and retraining across the course of a career. Many have pointed to the ways that technology has disrupted employment, making some jobs redundant while creating new ones that were previously unimaginable.

What 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 recognise as essential: innovation, creativity, entrepreneurship, and resilience. Education needs to produce people who can work in teams, demonstrate strong leadership and communication skills, and possess the ability to thrive
in diverse cultural and social contexts. This collection of characteristics, gathered under the umbrella term ‘21st-century skills,’ are rarely measured by most assessment regimes – a cipher unrecorded, as many of these reports note.

Not only do these skills go undocumented, many educational systems fail to teach them directly and lack mechanisms even to instil them indirectly. The pedagogical methods used in many educational programmes serve only the 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 systems no longer serve the needs of today’s society nor the current global economic system. How can education be redefined to accommodate for this more expanded understanding of essential skills and abilities?

Current 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 – followed by Piaget, Papert and others – have promoted for more than a century. But after all this time, how can we realise a system in which individuals are inculcated with the skills to thrive in more humane and inclusive ways that were once seen as 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 also require a more holistic definition of learning. Such a definition would note the transformative process of acquiring skills, abilities, experience, and knowledge, as well as the internalisation of these to form a new identity. While the acquisition of new information is an important part of the learning process, often leading to changes in behaviour and to new perceptions of the world, a narrower, more content-focused definition of learning tends to elide learning’s organic, ongoing nature. On the other hand, a more holistic definition emphasises not just the static measurement of what knowledge has been transmitted and absorbed, but also the processes by which knowledge is being constructed and internalised. The idea that knowledge acquisition could be considered part of a living process, constantly being created and recreated, 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 thus considers the individual learner to be a critical factor and agent in the creation of new knowledge. Such a definition recognises the contexts that existed before the learning occurred and the process of learning itself, as well as the value of the learner.

A more holistic definition also considers the ways that learning transforms each learner. Learning is manifested in the ways individuals apply and demonstrate the knowledge they have gained in their actions. Learning is thus less about acquiring information or submitting to another’s ideas or values than it is about finding one’s own voice and exchanging

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one’s ideas with others. A broader definition of learning considers the “qualitative change in a person’s way of seeing, experiencing, understanding, [or] conceptualising something in the real world” rather than limiting itself to the quantitative change in the amount of knowledge 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.

The more holistic definition of learning used throughout this discussion thus considers both knowledge as it is being shared and internalised and also the ways that such knowledge is being created and applied experientially. Far from being solely a catalogue of transmitted data, this definition embraces the processes, products, and resulting shifts in identity that learners manifest as they grow and develop.

**Defining constructionist learning**

In [Jean Piaget](/content/References/Piaget). JEAN PIAGET’s theory of constructivism, learning is based on experience and observation. Piaget (1896–1980) asserts that through experience – and through reflection on experience – individuals are able to construct new knowledge and new understandings of the world. Yet experience doesn’t happen in a vacuum: learners interpret their experience based on their own prior knowledge as well as the reported experiences of others. Because of this interplay between experience and reflection as the basis for building knowledge, constructivism argues that learning happens best when it is self-directed.

[Seymour Papert](/content/References/Papert). SEYMOUR PAPERT’s (1928–2016) constructionism builds on Piaget’s constructivist theory, proposing that learners construct mental models in order to understand the world around them. 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 in the following manner:

> From constructivist theories, 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 as constructing is a meaningful product.

According to constructivist theory, individual learners actively construct new knowledge based upon existing and innate knowledge. In other words, learners do not receive knowledge passively, but interpret what they receive and then modify it to a form they

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understand in order to construct new knowledge. Constructionist theorists and practitioners similarly maintain 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. Yet constructionism goes beyond the mere idea of learning-by-doing, emphasising the roles of both design and digital technology in facilitating knowledge construction.

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 learning. Kafai (2006) describes the artefacts that learners create as “objects-to-think-with,” where the designed artefacts “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,’ whereby knowledge is seen as a static, non-volatile object to be transmitted and absorbed. However, more than thirty years of research has shown that learners retain minimal information when it is delivered exclusively through instructionist methods, and they frequently experience difficulty in 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.

In order to provide greater opportunities for individual agency, constructionism proposes that teachers act as facilitators, coaching learners rather than subjecting them to lectures or step-by-step guidance. 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 learners make connections between different ideas and areas of knowledge provide an ideal environment for such learner-directed learning. This has led to momentum behind a number of ‘new’ learning movements, such as project- and problem-based learning and ‘maker’ education (all three of which are discussed in detail below).

Known as ‘active learning’ for their emphasis on learner creation, these constructionist methodologies oppose the passive reception and repetition of knowledge, yet they 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 higher-order and metacognitive thinking, many forms of constructionism may also involve group work, seeing collaboration as a means of driving skills and knowledge development while also offering opportunities to engender further reflection and observational opportunities that can drive metacognition.

Bonwell and Eison (1991) conclude that active forms of constructionist learning lead to better student attitudes and improvements in students’ thinking and writing. A meta-analysis by Freeman, et al (2014) on the impact of active learning in STEM classes shows that average examination scores improved by 6% in active-learning sections. In contrast, students in classes with traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning. In other words, lecturing – and the passive reception by students that it entails – increased failure rates by 55%. The benefits of active learning appear across all class sizes, although the greatest effects can be seen in classes with fewer than 50 students.

Boiled down to its essence, 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 understanding and 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.

**Problem-based learning**

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.

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in which learners construct 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 to resolve. 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 problems, telling them less so they can discover more.

Originally developed at McMaster University in the 1960s in an effort to make medical education more robust and engaging, problem-based learning often presents learners with a scenario or case. To find information that explains, answers, or resolves the problem presented, learners must conduct research in the content field, experimentally applying what they discover and submitting it 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 students’ 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 they must research in order to gain understanding – without direct guidance or intervention by teachers – problem-based learning seeks to make learning relevant to the real world. This emphasis on real-world relevance is also designed to generate positive engagement by learners and to improve their attitudes. It provides a natural environment for developing problem-solving and life-long learning skills. Research, like that carried out by Keziah (2010), confirms the beneficial impact that problem-based learning can have. According to Keziah’s 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 when 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 K–12 students, evidence suggests that it contributes to 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.

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Hung, Jonassen, and Liu’s (2008) review of problem-based learning in 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. 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.

Although they are meant to refrain from direct intervention, 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 a higher degree of effectiveness than less-experienced teachers when deploying student-centred pedagogies like problem-based learning. 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.

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. 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. 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 traditional pedagogies showed that medical students from problem-based schools graduated faster and in larger numbers.
On average, students in problem-based 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 student attitudes and opinions about the programmes. Data on student attitudes, student mood, and student 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 students exposed to problem-based curricula. Students 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.

Arambula-Greenfield (1996) observed a preference by college students for problem-based 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.

Nonetheless, 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. While problem-based learning may provide a more challenging, motivating, and enjoyable approach to medical education, he concludes that its 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 the positive impact that problem-based approaches could have on student academic achievement, it may not be possible to claim with a high degree of confidence that problem-based learning is more effective in increasing student content knowledge. Likewise, Sungur, Tekkaya, and Geban (2006) found no significant

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difference in the acquisition of factual knowledge between students 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 students taught by problem-based methods scored significantly higher on assessment items measuring their ability to organise and integrate their knowledge.

The relative scarcity of peer-reviewed studies investigating the effectiveness of problem-based learning for improving student academic achievement at the secondary level described by Wilder (2015) and others should give educators pause – especially given the increased prevalence of this instructional method in K–12 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 student achievement as measured by retention of knowledge and student achievement as measured by the acquisition of other skills (communication, critical thinking, problem-solving, etc.). The educational community needs more clarity about what is meant by ‘student achievement.’ In much of the research, student 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 student-centred, constructionist learning approaches involves the development of a range of skills above and beyond content knowledge – communication and collaboration, critical thinking, problem-solving, decision-making, and self-directed learning – segregating these achievements from accounts of formal academic progress helps to obscure and confuse learning gains that might otherwise be clear.

**Project-based learning**

Like problem-based learning, project-based learning (also sometimes referred to as ‘PBL’) is a learner-centred, constructionist approach focused on engaging learners in the exploration of 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. Within the project-based learning framework, learners design and create projects meant to address a challenge often posed by a teacher or external entity, though learners also sometimes participate in the selection. As Blumenfeld, et al (1991) describe it,

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.  

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

In investigating a problem and designing a solution, learners are asked to acquire broad and interconnected understandings of key principles and concepts. This stands in stark contrast to the more 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 the 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.

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 time is even more apparent when students create projects designed to link the classroom experience with real-life situations outside of school. Yet both the length of interaction and the variety of activities associated with project-based learning offer important benefits: unlike the more limited group of learners who excel at instructionist learning, project-based learning welcomes and can serve a wider variety of 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 two essential elements. First, it requires a question, problem, or issue, often provided by the teacher. This prompt serves to organise and drive learning activities, setting learners on a particular path. These learning activities result in 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. Second, project-based learning is organised 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.

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In a sense, the projects that students develop are irrelevant – they are certainly not the summative artefacts at the centre of many instructionist classrooms. In project-based learning, the projects are more ‘formative’ – a vehicle for learning. They provide the infrastructure within which learning occurs. Essentially, they 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.

Research on project-based learning indicates that it enhances student performance, motivation, and engagement. It drives increased teacher/student interaction and also promotes acquisition of the sorts of skills many people claim are necessary for success in the 21st century: creativity, critical thinking, collaboration, cooperation, and communication. For example, Mills & 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 might have come out of their courses with a less rigorous understanding of engineering fundamentals.

Research by Dole, Bloom, & Doss (2017) on the implementation of project-based learning among students in grades 1 to 9 showed significant improvements in students' 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 ways students approached and pursued topics, spending their own time to conduct extra research. This increase in engagement and enthusiasm resulted in situations where students did not realise how hard they were working or how much they were learning. The teachers interviewed in the study described how students showed an increased tendency to work toward mastery rather than simple task completion, becoming so immersed in their learning 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 improvements in student motivation, attitude, and engagement – along with the development of both collaboration and leadership skills – were clearly evident.

Ilter (2014) also found increased student motivation when a 4th-grade social studies class employed project-based learning. Unlike Mills & Treagust, Ilter found that students’ conceptual understanding of the subject increased under a project-based learning approach.


framework. In addition, project-based learning positively affected students’ conceptual achievement and motivation to succeed academically, compared to students who were taught by more delivery-centric, instructionist methods. Ilter’s results mirrored Gultekin’s (2005) research on the impact of project-based learning on grade 5 social studies students. Like Dole, Bloom, & Doss, Gultekin found that students 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 its 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. Evidence indicated that students who were exposed to project-based learning demonstrated increased content knowledge, enhanced motivation, and more productive group work skills. Significantly, the students exposed to project-based learning were also 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 students demonstrated a higher degree of engagement and motivation and outperformed their peers who were subject to more teacher-centric pedagogies. They found that project-based learning promoted student learning in a more integrated, holistic way than other pedagogical programmes. Students in problem-based classes demonstrated a greater ability to solve problems and a deeper level of understanding that crossed content areas, as well as a higher degree of engagement and motivation.

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 similar achievement for mathematics on a range of tests, with results from a national, standardised test of mathematics proficiency revealing no significant differences between the scores of students enrolled in either school. However, Boaler’s study revealed that once students were exposed to project-based learning, they began to regard mathematics as a dynamic, flexible subject requiring exploration and thought, as compared to students at the control school, who viewed mathematics as boring and tedious. Moreover, students at the project-based school performed as well or better than students at the control 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 control school. Overall, significantly more students 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.\(^{51}\)

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.\(^{52}\)

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, students in the project-based curriculum outperformed students in the instructionist setting on post-unit assessments. Second, the project-based approach resolved disparities in scoring among students from underrepresented demographics as well as between males and females. And finally, their research showed that teachers were more likely to engage with students in project-based classes, with teacher/student interactions increasing significantly over time as compared to those involved in instructionist classes.\(^{53}\)

However, not all of the studies have shown the same positive results. Johnson & 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 a social studies, science, or mathematics classes.\(^{54}\)

‘Maker’ learning and ‘maker spaces’

The ‘maker movement’, like project- and problem-based learning, is another example of an active-learning methodology. Also a form of constructionism, ‘maker’ education is based on

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learners developing an idea and then designing and creating an external representation of that idea. As with other constructionist approaches, it is heavily learner-centric, with learner agency at its theoretical 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 a variety of locations that are collectively labelled ‘maker spaces.’ Classrooms, museums, libraries, studios, homes, or garages may all serve as maker spaces. What distinguishes them 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.” More than either problem- or project-based learning, maker learning takes very seriously the social aspect of constructionism that argues “learning happens best when learners construct their understanding through a process of constructing things 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 now well recognised, educators are still wrestling with ways to integrate it into the more formal curricula that dominate most schools. Part of the reason for this difficulty is that ‘making’ bridges the divide between formal and informal learning, pushing practitioners and educators to think more strategically and expansively about where and how learning happens. Maker education’s blurring of the lines between formal and informal learning also means that some of the mechanisms by which schools have sought to measure or guarantee learning also need to 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. Maker education works to prepare learners for the real world by giving them opportunities to approach, consider, and address real-world challenges, making whatever solutions or projects they feel are appropriate. Because of this, as pioneer of the maker movement, Dale Dougherty,

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explains, when an individual generates such a project, the object itself demonstrates what the individual has learned, and thus provides the best evidence of learning.60

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 products. Maker spaces frequently incorporate new technologies and innovative processes, encouraging participants to take advantage of them as they design and build projects.61 What is essential for maker spaces is that they all involve and facilitate ‘making’—helping people develop an idea and construct it in some physical or digital form.62 In order to develop their projects, learners must use a range of knowledge and experience holistically, breaking down disciplinary boundaries and learning to work with a range of tools, materials, and processes.63 By design, maker spaces are thus ideal venues for the development of projects that do not fit neatly into narrow disciplinary or subject areas. They encourage participants to collaborate, remix, extend, and invent, often combining multiple approaches and knowledge areas in the projects they produce.

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 thoroughgoing exploration. As a learning approach, ‘making’ is designed to foster enthusiasm for learning, learner confidence, and natural collaboration.64 Community in the maker space serves as yet another crucial resource for the achievement of these goals. Ultimately, the aim of maker education and educational maker spaces is the generation of learners who are determined, integrative, creative, and critical thinkers.

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, and 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.”65

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, it works to break down traditional distinctions between vocational and academic education.66

This expansive definition means that maker learning seeks to produce far more than a project completed 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 by becoming makers themselves. In this enterprise, the maker space serves as both the site and the vehicle for learning—a space that shapes learners’ expertise and offers them opportunities to demonstrate that expertise and guide others in developing it. Maker learning’s preparation of learners to be creative, innovative, self-actualised, collaborative, and technologically literate has suggested to some, like Stager (2014) that ‘making’ should not be seen as an alternative way to learn, but rather as the epitome of what modern learning should look like.67

The diversity and emphasis on productivity of maker learning and maker spaces means they can be adapted to fit many learning contexts. 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.68

While data on increased academic achievement due to ‘making’ is not conclusive, research indicates that this learning approach has a positive impact. 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 also indicated that ‘making’ positively impacts student creativity, confidence, initiative and innovative thinking, and demonstrated to a lesser extent that it can increase student performance and grades.69

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’ 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, which can equip them to enter the workforce as skilled workers.

**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 or 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 learning. Within the constructionist paradigm, 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 own personal insights, knowledge, and experiences to the 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, developing autonomy and mastery as they construct their 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 in the classroom, providing a forum where they can share information with their peers. By providing a platform for learners to share what they are discovering, learner-centred approaches provide richer 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 all of the resources and approaches that other learners bring. 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.

By giving learners the responsibility to dialogue with teachers and peers in a way that directs and expands their learning, learners are able to practise the skills they will need for learning outside of formal schooling – honing abilities that will serve ‘lifelong learning.’ The dialectical approach, in which learners address their own open-ended questions and must address open-ended questions from others, exposes them to critical and metacognitive thinking and offers them opportunities to encounter and respond to contradictions in their developing understandings of the world. By calling attention to the way learning is shaped through dialogue, these methods remind learners that they need others to refine and develop their thinking. Eventually, such experiences are designed to give learners the skills, resources, and agency for complex problem solving and productive collaboration.

71 Wright (2011). “Student-centered learning in higher education.”
Of course, learner-centric education exists on a continuum; some activities or practices might 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 success. Similarly, instead of being assessed against an arbitrary measure of content retention, learners’ success should be measured by examining their ability to demonstrate their learning in the creation of real-world projects.

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 students regularly prompted to explore, research, defend, and challenge information. Learners 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 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 classes of 2011 and 2012 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 high percentage – one that exceeds state averages.

Other research on learner-centric approaches shows that they can have a positive impact on learning. A study by the Nellie Mae Education Foundation (2015) examined the impact of technology in facilitating student-centred learning for STEM subjects. Students experienced blended-learning practices, with teachers acting as facilitators, and they also participated in experiential learning, supported by outside professionals. Compared to students not involved in these educational modalities, the study showed that students in the learner-centric programme achieved higher scores on science achievement tests. Gains were particularly significant among underserved students: female students, racial minorities, and students receiving free or reduced-price lunches (indicating they come from low-income backgrounds).

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-centric techniques. Students in the more learner-centric classes reported both higher levels

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of engagement and higher levels of 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 math test. Holding prior math achievement as a constant, students in the more learner-centric classes scored significantly higher.  

Social learning theory and collaborative learning

As developed by Albert Bandura (1925–), social learning theory contends that learners can internalise new patterns of behaviour not only through direct instruction or experience, as well as by observing others. When individuals observe others who model a particular behaviour, they can observe how that behaviour is performed; on later occasions, these observations can then function as a guide, enabling the individual to replicate that behaviour. 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 particular information through other means, providing an appropriate model considerably shortens the process of learning.

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.

Because of its model of observation, internalisation, and expression, social learning theory creates a supportive atmosphere for learner-centred education and offers a useful means for observing learners’ growth. Carrington & Selva’s (2010) study, for example, explored the ways social learning theory informed the reflection process used by a group of pre-service teachers to consider their growth when they engaged in service learning. The study showed that the implementation of this socially informed reflection taught the

77 Nellie Mae Education Foundation (2015). “Centered on results.”
learners important critical thinking skills. A study by Palloff and Pratt (2007) concluded that the scaffolding of collaborative skills helped learners achieve a deeper level of knowledge while moving from independence to interdependence.

Kumpulainen & Way (2002) assessed the impact of social learning on language development, comparing teacher-centred with peer-centred (that is, 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 peer-centred class. Although some might otherwise be tempted to dismiss it as a factor, Kumpulainen & Way showed a strong correlation between group discussions and children’s oral language development.

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.

Experiential learning and the ‘crucible’ of experience

Educators define ‘praxis’ as the unification of knowledge and behaviour 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.’

David Kolb (1939–) describes experiential learning as a holistic, integrative learning methodology that combines experience, cognition, and behaviour. In his conceptualisation, learning is a process where learners derive concepts and continuously modify them through experience.

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 by which observations and reflections can be transformed 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 in order to develop judgment – which he classifies as a combination of what is observed with what is recalled. Piaget (1896–1980) stressed that learning is a mutual interaction between experience and conceptualisation in which 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 crucible of learning.

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 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 the classroom: learning touches all aspects of life across all life stages. Considered holistically, learning is best understood 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’: it 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 – the accumulation of an individual’s subjective life experiences – and social knowledge – 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. A study of experiential learning by Mainemals, Boyatzis, and Kolb (2002) 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 in their learning developed higher analytical skills, while those who focused on experiencing developed higher interpersonal skills.

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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.⁸⁹

**On the benefits of instructionism**

While significant amounts of research support constructionist learning methods, other studies support the 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. While these studies contend that instructionism may be superior to constructionism for the acquisition of knowledge in new fields⁹⁰ other empirical studies make a broader, research-based case, arguing more generally against the use of learner-centric methodologies that offer minimal guidance. For example, Mayer (2004) concluded that the “debate about discovery has been replayed many times in education, but each time, the evidence has favoured a guided approach to learning.”⁹¹

Studies conducted almost a decade apart by Hardiman, Pollatsek, and Weil (1986)⁹² and Brown and Campione (1994)⁹³ 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 researchers concur. For instance, Moreno (2004) concluded that students learn more deeply from strongly guided learning than from discovery.⁹⁴

In another study, Klahr and Nigam (2004)⁹⁵ tested not only whether science learners learned more 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 vastly more learning than a learner-centric, discovery approach. Those relatively few students who learned via discovery showed no signs that their learning was of superior quality.

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Studies by Roblyer\(^{96}\) (1996) and Perkins\(^{97}\) (1991) also examined evidence about the results of minimally guided 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 minimal guidance, discovery approaches and both suggested that some form of stronger guidance was necessary for both effective learning and for transfer.

Kirschner, et al (2006) similarly argue that after a half-century of advocacy for instructional methods involving minimal guidance, research supporting the benefits of these learning approaches is sparse. In addition to claiming that evidence supports direct instruction and strong guidance for the instruction of novice and intermediate-level learners, these researchers also contend that strong guidance typically proved to be just as effective as unguided, discovery approaches even for students with considerable prior knowledge. Their research suggested that unguided instruction was typically less effective and they found evidence that it might even have negative results, resulting in learners acquiring misconceptions or incomplete or disorganised knowledge.\(^{98}\)

As they observed, this was often the result of practitioners who favour minimally guided instruction paying little attention to the characteristics of and intricate interplay between working memory and long-term memory. The researchers concluded that the 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 are unlikely to result in effective learning.\(^{99}\)

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’ (that is, more instructionist teaching) when students failed to make progress in a learner-centric, discovery setting. 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.\(^{100}\) According to Aulls, evidence from well-designed, controlled studies supports direct instruction over learner-centric methods.\(^{101}\)

**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 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 them the power to apply their learning in the design of applications would result in engagement. As he described it, computers were “material to be messed about with,” a resource that encouraged exploration and learning. Although integrating them posed technological, procedural, and pedagogical challenges at the time, he believed these were worth overcoming because incorporating both computer technology and what we now call ‘coding’ increased the willingness of learners to learn. 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 nor on the applications and software learners generated, but on the learners’ minds – on their growth and development.

Rather than a bunch 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.

More and more kids have had computers from the day of their birth, who’ve gotten used to using them [and] have used them to have very, very rich learning experiences. [We are] beginning to get a peppering of these kids in our classrooms. And that is a real army to bring about change, call it “Kid Power.” Kids are coming into school and saying, “We want something better than this.” They are not only demanding, they’ve got the know how [saying to their teachers],”We’ll show you how to do it. We’ll help you.”

However, Papert was very 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 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 they wanted.

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. But 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.¹⁰⁷

Embracing and incorporating technology brings important opportunities, but doing so requires thoughtful consideration of the learning structures in our schools, of the role and nature of assessment, of the power dynamic between and among teachers and learners, of the conceptualisation of what we mean by the school ‘community,’ and of the nature of assignments and projects. It cannot be done in a segregated or bolt-on way; adding it to the recipe of learning changes – and must change – the entire flavour.

**Final thoughts**

What comes clearest from the collection of research conducted over the past thirty years is a picture of the complexities involved in learning research. Nearly every study – no matter its focus or results – can be qualified or countered by another study. Yet a number of unambiguous patterns have also emerged.

**Teachers who are not adequately prepared** or equipped can negatively impact any learning environment. Research has repeatedly demonstrated a clear connection between teacher preparation and the success of any learning method, even for learner-centric approaches.

**Learners who do not play a significant role in designing** their learning and who do not create meaningful projects as part of their learning view the learning process negatively, regardless of how well they might perform on various assessments. They perceive education as boring, irrelevant, or hollow, lacking the ability meaningfully to impact their daily lives.

**Assessment that serves primarily administrative** or bureaucratic purposes can negatively impact the learning environment. 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.

**Learning approaches that are more holistic**, requiring more than learners’ intellects, and that build connections and leverage opportunities beyond the classroom’s walls are more likely to engage learners and to give them positive perceptions of the learning process.

Socially rich learning environments that connect learners with a network of experts, practitioners, and interested parties to whom learners can demonstrate their learning and who serve as sources of information, critique, and encouragement produce learners who are more able to apply their learning in contexts beyond school, more likely to persist in their learning, and more able to adapt to situations for which they were not prepared by formal educational systems.

Much work remains to be done in the ongoing task of refining education, and more studies will be necessary to clarify precisely what path learning should take. However, the momentum behind making and constructionism and the congruence of these approaches with the new generation of technological tools available to teachers and learners offers a clear indication of learning’s future direction.

Constructionist methodologies offer important chances for learners to collaborate across disciplines, apply their learning in novel or 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 prospect: the chance to harness the energy of young learners and the excitement inherent in their learning to make positive changes and to solve actual problems in the real world.
2 · Annotated Bibliography

**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 constructionism does not view knowledge as a commodity that can be transmitted, encoded, retained, and reapplied. Instead, knowledge is
constructed out of personal. Understanding that knowledge is formed and transformed within specific contexts, shaped and expressed through different media, and processed in the minds of the learner, Papert always focused on the fragility, contextuality and flexibility of knowledge under construction.


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 Paper 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


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.


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.

**Project-based learning**


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.

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.

Making and maker spaces


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.

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.

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.

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.

**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 combines 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 concepts. 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 second is based on the Dewey model. This second form emphasises the developmental nature 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 dialectically 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.

**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.