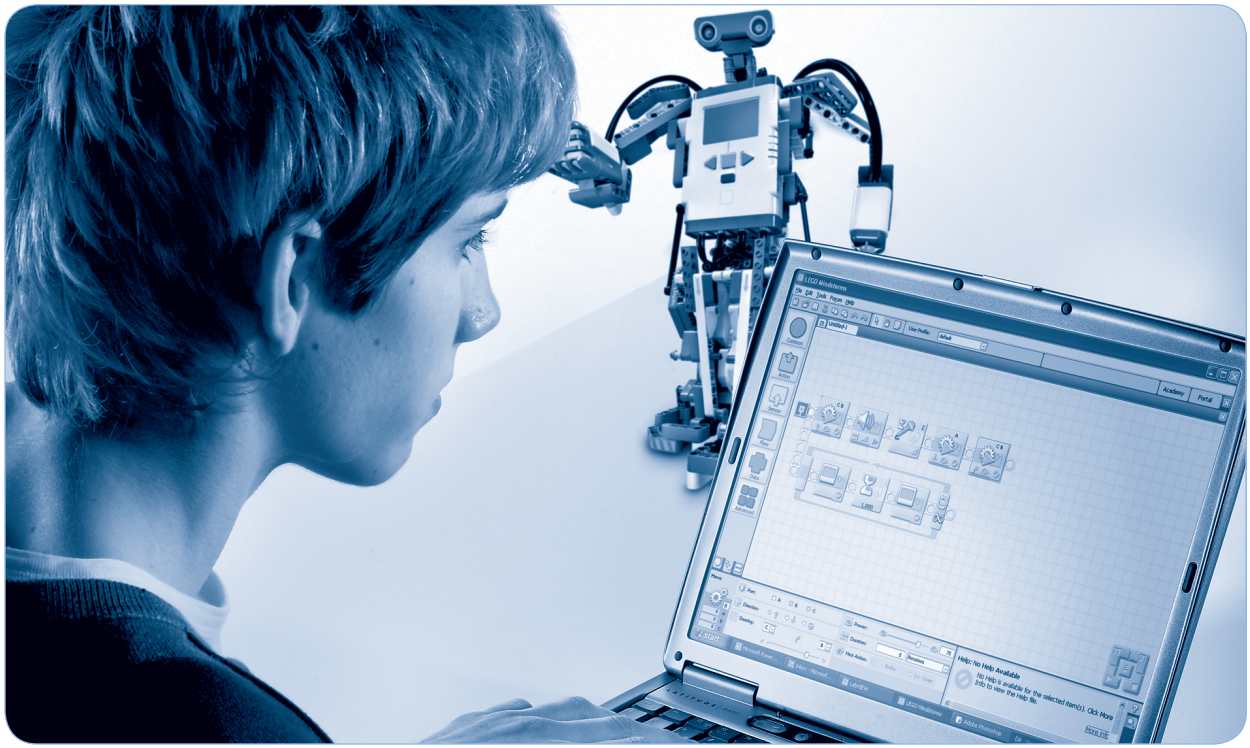
4. Education and Training



From the abacus to the slide rule to the computer, technology has always played an integral role in education—but information technology (IT) has now advanced to a point where it allows for fundamentally new and exciting improvements in the learning process. As discussed in this chapter, new online applications and tools have emerged with the potential to transform education by improving learning outcomes, serving multiple learning styles, and expanding access to education.

Learning software gives students instant feedback and individually tailors instruction in ways that a classroom teacher never

could. Flexible online classes give people access to education that would never have been possible before the Internet. Parents now use the Internet to follow their child's school assignments and academic progress through Web portals. Companies use technology to save on workforce development costs. IT has made all of these and other innovative applications possible and promises to continue to rewrite the rules of what is possible in education and training.

It is one thing for a host of new e-learning applications and tools to emerge, but do they make a difference in the education of students? Advocates of IT in schools have long hailed the promise that IT can help reshape education, improving learning outcomes and student opportunities while saving money. With so much at stake, researchers have labored for years to determine the effectiveness of a variety of educational technologies—and their results are conflicting. The final section of this chapter reviews available studies and concludes that the effectiveness of using IT in the classroom will depend on the implementation, curriculum, and the pedagogical approach used by the teacher.

Improving Learning Outcomes and Serving Multiple Learning Styles

Perhaps the most important and widely cited IT-driven change in learning is in allowing individuals to learn more, both in the classroom and in the home. Though the history of educational technology is not a story of unqualified success in improving learning outcomes, the latest—and most sophisticated—applications of IT have been shown to yield results, while also helping to dramatically reshape the learning process.

Many IT applications and tools can make learning more effective for students. For the youngest students, preschoolers, IT is making toys more interactive and engaging. Today, many toys have integrated circuits in them to enable children to interact with them. Fisher-Price's Learning Phone, for example, helps teach babies and toddlers the alphabet using audio, an LED screen, and lighted buttons.[1] Fisher-Price also makes online games for babies and toddlers available free, including games that help toddlers learn letters, numbers, names of animals, sounds of musical instruments, and other things.[2] Additional technology toys include everything from LEGO Mindstorms, which let kids build and program real robots, to a handheld microscope that plugs directly into a TV to display magnified images.

For children at the K-12 level, a wide array of IT applications lets students learn more effectively. A host of new "intelligent" tutoring programs—like Carnegie Mellon University's "Cognitive Tutor," software—teach a variety of subjects at different levels, from foreign languages to physics. Research has shown that such tutoring programs can improve students' performance as much as one letter grade. The software may accomplish less than a human tutor can accomplish, but at $30 to $60 a student, the software is also significantly less expensive.[3]

Software and Internet applications give students access to new information and opportunities. The JASON Project, a nonprofit subsidiary of the National Geographic Society, connects students with great explorers and great events to inspire and motivate them to learn science. Its interactive website offers students the opportunity to follow along virtually with real scientists (via webcasts, interactive simulations, chat sessions, etc.) as they research, for example, the science behind megastorms.[4] Students participating in the JASON Project design experiments that use real cutting-edge scientific data. Research shows that simulation tools in science classes have the potential to help learners grasp more complex, higher order concepts.[5] An educational game called "Immune Attack," for example, is designed to engage students by battling virtual viruses inside a body while exploring concepts in immunology.[6]

New tutoring software allows students to proceed at their own pace. A software package used by the Success for All Foundation to assist tutors of first grade students with reading difficulties, for example, is "Alphie's Allie." For the student, this software program uses multimedia to represent concepts and sounds and provides continuous feedback on reading performance. For the tutor, the program suggests tutoring plans tailored to student performance, offers professional support and guidance for how to best undertake activities with the student, even including videos of expert tutoring techniques. Moreover, the software's level of involvement in the tutoring

session is flexible, based on the needs of the tutor and the student. One evaluation found that students in a program that used "Alphie's Allie" along with a multimedia program improved their reading by over a half a standard deviation compared to a control group.[7]

Games for children designed to double as learning tools have proliferated. Discover Babylon, for example, is a game that involves exploring the history of Mesopotamia to complete a series of challenges.[8] The Oregon Trail game teaches history and geography while engaging students in a set of tasks and challenges that expose them to pioneer life in the early 19th century in America. In addition, websites such as FunBrain.com offer children online games and activities that reinforce skills and subjects taught in schools. Many organizations also develop special "kid-friendly" websites that blend the line between education and entertainment. The U.S. Government Printing Office, for example, developed "Ben's Guide to U.S. Government" to provide age-appropriate instruction, activities, and games to teach children about how the government works. Even the Nobel Foundation makes games available on its website to teach students about the work of different Nobel Laureates.[9]

Educators can find many useful resources on the Internet, too. The website Curriki, for example, provides a platform for educators to design and share curriculum that benefits students and teachers around the world. Similarly, websites like TeachingBooks.net provides teachers and parents learning guides and activities for popular children's books as well as online videos of authors and illustrators of children's books to encourage children to read. Other online resources, such as Enchanted Learning, use multimedia to engage children's creativity to teach about nursery rhymes, inventors, music, and other subjects. TumbleReadables is a series of online books that allow children to read along with the story and get help with words that are difficult for them.

Beyond helping students and teachers, IT is making it easier for parents to become and stay more involved in their children's education. Innovative online programs like Edline can help parents to keep tabs on their child's performance and academic progress in school. In a growing number of school districts, teachers use Edline's Web portal to communicate with parents by posting homework assignments, test dates, and other relevant information.[10] Armed with a greater awareness of their child's performance in school, parents can play a more central role in the learning process.

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Recently, the deployment of fast broadband connections has been stimulating the use of the Internet for educational purposes. In 2005, for example, a quarter of all Danish Internet users in broadband households used the Internet for educational activities whereas only 14 percent of users in non-broadband households used it.[11] In the European Union, there is also a clear relationship between the percentage of teachers using IT in teaching and the percentage of schools with broadband connections.[12]

In a very powerful sense, IT offers the promise of fundamentally rethinking our current approach to education. For longer than any of us can remember, schools have been oriented around the traditional classroom, with a teacher leading a group of students through lessons and activities. This model owes its ascendance largely to expedience, not any pedagogical superiority. But the advent of advanced IT opens the door for alternative models. Advocates of "constructivist learning"—which "emphasizes active participation and reflection by learners, who should control the pace of instruction and construct knowledge by themselves"[13]—argue that IT can put the student at the center of the learning process, with the teacher facilitating each student's tailored learning experience. Others have suggested harnessing technology in ways that actually inspire students to learn and conduct their own inquiries outside of the framework of traditional classes and standard-

ized tests.[14] The key contribution of IT is that can allow the student's interests, needs, strengths, and weaknesses to drive the learning process, with the instructor facilitating rather than dictating.

When learning and teaching are done largely through teachers in the classroom, the ability to customize learning to the needs and abilities of individual students is limited. As a result, in traditional classrooms some students will struggle to keep up, while others will be bored and want to jump ahead. One of the benefits of IT is that it lets materials be designed much more around the needs of individual students.

Expanding Access to Education

Beyond offering greater choices to students in how they learn, IT offers greater choices to students in what they learn. Distance education, for example, expands the course catalogue for existing students, which has proven especially important in the K-12 context. Online learning gives a student at a small school in rural Idaho, for example, access to Chinese language or Advanced Placement courses her school does not offer. The power of this transformation should not be underestimated: As the online course catalog grows, it is conceivable that at some point in the near future every high school in the country will be able to offer students a course in every conceivable subject.

Such IT technologies are not just for youths; they are also helping adults learn. Corporate e-learning first became a major phenomenon about 10 years ago. Companies spent millions on software that moved teaching online, but the early products were too often ineffective, decidedly user-unfriendly, and simply boring. In the past decade, however, much has changed. In the past few years, firms have been successful with more sophisticated approaches, often blending tailored online learning sessions with classroom learning.[15] As a result, they are investing more in it. Among a sample of Fortune 500 companies and large public sector organizations, technology was used to deliver 37 percent of formal training in 2005, up from 24 percent in 2003.[16]

IBM's "Basic Blue" manager training program couples Web modules and simulation management exercises with classroom learning to achieve impressive efficiency gains: Studies have shown that the program costs one-third as much as a traditional classroom approach and managers learn five times the amount of material.[17] Recently, firms have begun to embrace a variety of new tools, including those that allow for peer-to-peer learning among coworkers. Indeed, blogs, wikis, podcasts, and collaborative software are becoming important tools for employees to exchange ideas and share insights.[18] IBM's WikiCentral, for example, has grown to include more than 12,000 users since its launch in 2005.[19]

Medical training has also begun to rely more on IT for various uses of e-learning. Medical students can now use high-fidelity simulators—lifelike robots that breathe, talk, and respond to treatments—to learn clinical and technical skills without the risk inherent in real-life patient encounters. These simulators enable students to practice and react to both common and rare events, and allow trainees to safely explore noncognitive skills such as ethical decisionmaking, cultural awareness, and communication skills.[20] E-learning also enables faster and more efficient training for health care workers than is possible through traditional education methods. One example is a nurse training and certification program implemented in Kenya in 2005 to upgrade the skills of 22,000 enrolled nurses to registered nurses over five years. Enrolled nurses make up almost half of Kenya's health care workforce but lack many of the basic medical skills needed to treat critical diseases such as HIV/AIDS, malaria, and tuberculosis. Previously, a shortage of instructors and facilities meant that only a few hundred nurses could be trained every year. By developing computer-based

IT allows the student's interests, needs, strengths, and weaknesses to drive the learning process, with the instructor facilitating rather than dictating.

training modules that can be accessed from computers placed in hospitals throughout the country, Kenya has been able to rapidly address the country's critical nurse shortage.[21]

Recognizing that many workers do not relish spending their time undergoing corporate training, learning models often place a premium on holding a user's interest. As a result, simulators are gaining popularity. Enspire Learning, for example, offers an executive leadership training simulator aimed to achieve higher retention rates. In the computer simulation, teams of corporate executives compete to manage virtual companies by performing a series of tasks. Players are promoted or demoted based on their performance.[22] In another application of gaming, Quiznos sandwich shops have incorporated a "Sub Commander" game simulator into its blended learning program for its retail workers. In the game, trainees are challenged to apply their learning to constructing increasingly difficult sandwiches.

Moreover, online learning not only is effective but can be cheaper than in-person, classroom learning. Though the initial expenses of online learning programs can be high, companies save over time on course materials, employee travel, and instructor fees. As a result, the savings for online programs generally add up to about 50 percent. Caterpillar has managed to achieve even greater savings with its online training programs, which cost only one-third as much as classroom methods.[23] With online learning, IBM found in 2004 that it had saved $579 million over the last two years.[24]

IT is also reshaping how adults outside of organizations are learning. The growing phenomenon of online learning is one of the more important ways that technology is reinventing education. In online classes, educators deliver lectures or other educational content via Internet video or podcasts, which students with a broadband connection can often experience at a time of their own choosing. Some classes even take advantage of messaging software to incorporate discussions, either as asynchronous posts or real time discussion forums or chat rooms. And with the proliferation of institutions like the University of Phoenix, online learning is growing rapidly. In fact, more than 3.2 million students took online higher education courses in the fall of 2005—an increase of 35 percent over the previous year.[25]

Online education has become popular for a variety of reasons. First, distance learning powerfully expands educational opportunities for people who may be physically unable to attend an educational institution because they are busy with work or children, are disabled or incarcerated, or live in a rural area where the courses they want to take are unavailable. Indeed, research suggests that postsecondary students taking advantage of distance education are far more likely to be employed full time and taking classes part time than other students.[26] Mothers, in particular, have been drawn to online learning because of the flexibility it offers.[27] In order to accommodate both students and curricula with different requirements, there is no uniform model for online learning. Some courses are completely online, with no face-to-face contact between instructor and students, while other courses mix or supplement in-person sessions with online instruction.

In some cases, institutions offer online courses because online courses—especially those that can be scaled to serve many more students than could be served in a traditional classroom—are more efficient than traditional courses and can therefore cut costs. Online courses save classroom space, and the number of students in a class becomes less important when lectures are recorded as Web videos or podcasts. At the University of North Texas, for example, there are no caps on class size for online courses.[28] If an institution of higher learning can teach more basic introductory courses more efficiently, professors can as a result spend more time teaching the upper level courses that require more interactive class time.

In addition, online learning is not limited to the content available in formal classes. The Internet puts an unprecedented amount of information at one's fingertips. With an Internet connection and a healthy dose of self-motivation, anyone can learn about a range of topics. These include topics related to activities of daily living—for example, it takes only a few clicks to find a Web video demonstrating how one can reset a Palm Treo smartphone (of particular use to visual learners who might have trouble with owner's manuals). And they also include more academic learning opportunities such as "iTunes-U," Apple's clearinghouse for free lecture podcasts from leading universities. Other online learning programs target individuals in need of remedial learning. One

such program is AlphaRoute, an online learning environment that helps boost adult literacy, which has been funded by the government of Ontario, Canada. The AlphaRoute program supplements online courses with discussion boards, live chats, and e-mail to foster interaction between students, instructors, and mentors. It includes special guidance for deaf students who can access online video to teach them American Sign Language.[24]

Student autonomy, though often an asset, can sometimes be a drawback to online learning. Autonomy allows for flexibility, but some students may lack motivation (as some studies have shown) or feel isolated if their only contact with instructors and other students is virtual. These concerns are serious and legitimate, and not all students are necessarily suited to learning in a virtual world. Still, distance education is moving in a direction that allows for greater interaction, minimizing such problems. New social software like Writeboard and InstaColl allow students to engage in virtual collaboration on group projects for which they can collectively write and revise documents over the Internet. Similarly, online classes are increasingly taking advantage of blogs, wikis, podcasts, and streaming media to increase collaboration and interaction between students.[30]

The Effectiveness of IT in Schools

Advocates of IT in schools have long hailed the promise that IT can help reshape education, improving learning outcomes and student opportunities while saving money. With schools spending $6.8 billion annually on instructional technology,[31] however, recent studies that call these claims into question have made the subject increasingly controversial. At a time when many schools are chronically underfunded, the question of whether computers are worth the investment is an important one.

Several recent overarching reviews have documented that teaching with technology in the classroom constitutes an improvement over traditional instruction. In a meta-analysis review of 20 studies of middle-school students, Pearson et al. (2005) found that technology has a positive effect on reading comprehension.[32] Waxman et al. (2003) concluded in a meta-analysis of 42 studies that technology had a small but significant positive effect on student learning.[33] Kulik (2003) examined a range of studies that evaluated technology programs for reading, writing, math, and science. Kulik found that several programs for math, science, writing, and particular kinds of reading software improve student outcomes.[34] In addition, various studies in Organization for Economic Cooperation and Development nations have found that Internet access can help make educational online activities more attractive and lead to improved educational performance.[35]

Not all academic studies have endorsed the view that IT improves students' educational outcomes. In 2004, for example, Rouse et al. evaluated a cutting-edge, scientifically based reading program for students with reading problems called *Fast ForWord*. This program is designed to "retrain the brain to process information more effectively through a group of computer games that slow and magnify the acoustic changes within normal speech."[36] Rouse et al. found in their randomized controlled evaluation that the program does not actually improve reading skills.

Fuchs and Woessmann's 2004 analysis of the relationship between the availability of computers and student learning, based on data from the Programme for International Student Assessment dataset from 32 mostly developed countries, found an inverse relationship between the availability of a computer at home and student achievement and no relationship between computer availability at school and student achievement.[37] But Fuchs and Woessmann's findings were convincingly refuted in 2005 by Bielefeldt. Bielefeldt observed that Fuchs and Woessmann's dataset is inadequate for drawing meaningful conclusions because the mere presence of computers does not tell us very much. He noted that the effectiveness of using computers will necessarily depend on implementation, curriculum, and the pedagogical approach of the teacher.[38]

In 2007, a highly publicized U.S. Department of Education report on a controlled study involving 9,424 students from three grades cast widespread doubt on the effectiveness of reading and mathematics software products in the classroom.[39] This study found no statistically significant difference between the performance of students in classrooms using 16 different reading and math software products and students in conventional classroom environments.

The Department of Education's assessment is certainly a chilling one for people hoping that IT will bring dramatically improved educational outcomes, but do its findings mean that spending on classroom technology is for naught? Not really. It is important to note that the study has several limitations, which may have affected its results.

First, the students using the reading and mathematics software products in question in the surveyed classrooms spent only between 40 and 50 hours using the products throughout the entire year—or about 15 minutes for each day of school instruction. For the overwhelming majority of their time at school, these students received exactly the sort of education as their counterparts in conventional classrooms, so it is no wonder they did not perform dramatically better. Indeed, a recent survey of computer usage in two districts—both with fewer students per instructional computer than the national average—found that students actually use computers for only about 2 percent of the possible time in a day. The authors concluded that "expecting to see substantial impact on students from the usage of any tool or strategy that is 'in play' only a few hours over a semester is probably unrealistic, no matter how powerful or important the tool might be."[40] Using computer technology for 15 minutes a day is a start, but the real power of IT will be unleashed only when we begin to fundamentally rethink the entire learning process in a way that maximizes its potential.

Second, learning outcomes are naturally tied to teaching pedagogy. Experts often speak of technology as "scaffolding" for learners, supporting them as they build their conceptual base. In this sense, technology is simply a tool of implementation, albeit a tool with powerful possibilities. A useful distinction can be drawn between so-called "Type I" educational technologies, which closely mirror the activities a teacher might have students perform; and the revolutionary potential of "Type II" educational technologies, which allow educators to radically reengineer teaching methods in "new and better ways" that would not otherwise be possible.[41] A Type I computerized reading program that closely mirrors the activities a teacher might have students perform probably will not achieve dramatically different results even if it makes learning easier, faster, or simpler. A Type II program, on the other hand, by allowing students to individually explore topics in ways best suited to each student's particular learning style or offering students instant feedback according to which future lessons and activities can be tailored, might achieve much better results. The Department of Education's study did test some award-winning software programs that incorporate Type II features (e.g., "Cognitive Tutor," which allows for tailored learning), but results for specific applications were not reported.

The effectiveness of using IT in the classroom depends on the implementation, curriculum, and the pedagogical approach used.

It is important to understand what so-called "technology immersion" does and does not do. Giving every student a laptop will not magically reinvent the learning process. A study of one such program in Texas schools found that teachers in classrooms with a laptop for every student still focused on imparting factual knowledge rather than in-depth concepts, while simply employing computers for similar tasks that students had formerly done with pen and paper.[42] Nonetheless, some studies show that the ubiquitous presence of computers can bring benefits, even when used in these traditional ways. Several studies show, for example, that student writing improves in such situations, likely because students engage in more written communication and use of word processing.[43]

What about the effectiveness of computers and the Internet at home? Although IT-enabled learning has benefits for all ages, most of the claims about computers in the home focus on children. Whether children who have access to computers and the Internet in the home gain an academic advantage over those who do not is a subject of debate. On one hand, using a computer to read webpages or engage

in text-based communication requires users to exercise reading and writing skills, and many computer games for young users are designed to boost learning. On the other hand, if children use computers primarily for entertainment, there may be few benefits. As is the case for computers in schools, it is not the presence of computers but the way they are used.

Unfortunately, most of the studies that examine the issue of home computer ownership do not address the type of computer usage. Still, the results of most studies are positive. The best evidence of the importance of computers is documented by Jackson et al. (2004). They find that home Internet use for children between 10 and 18 improved performance on the standardized reading tests, likely because Internet usage depends so heavily on reading text.[44] In 2005, Fairlie concluded that, after controlling for family income, parental education and occupation as well as other factors, a home computer improves the chances that a teenager is enrolled in school.[45] Other recent studies have found a positive link between computer ownership and student performance,[46] and asserted that computer use during early childhood is related to cognitive development and school readiness.[47]

The results with regard to adult online learning are even more positive, although some higher education faculty members are skeptical of its benefits.[48] Nevertheless, the evidence indicates that in many cases online learning is as effective as a traditional classroom environment, while innovations in online learning continue to add more functions to the online classroom, promising to confer even greater benefits.

In 2001, in the most widely cited assessment of distance learning, Russell examined 355 studies and reports, concluding that there is "no significant difference" between online courses and traditional classrooms in terms of students' performance.[49] Subsequent reports have largely confirmed this finding. In 2004, Cavanaugh et al. published a meta-analysis of 14 scientifically based research studies of distance learning in K-12 classrooms, the conclusion of which was that students in online courses do not perform better or worse than their counterparts in traditional classrooms.[50] Another 2004 study of distance education at several academic levels found no significant difference,[51] while a 2006 meta-analysis of 25 comparative studies of distance education in allied health science programs found that distance education actually had a slightly positive effect on student performance.[52] In fact, a handful of studies have found that students in online classes at various levels perform better than traditional students, but the methodological rigor of several of these studies raises questions.[53]

In sum, the effectiveness of using IT in the classroom depends on the implementation, curriculum, and the pedagogical approach used. In school, at home, and at work, IT has the potential to make learning more effective, easier to access, and often more cost-effective. In all of these areas, IT is driving fundamental changes that promise to improve learning outcomes, and ultimately, improve our lives as a result.

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Technological innovation, particularly in information technology, is at the heart of America's growing economic prosperity. Crafting effective policies that boost innovation and encourage the widespread "digitization" of the economy is critical to ensuring robust economic growth and a higher standard of living. However, as in any new and changing situation, policymakers have varied awareness of what is needed and what will work. In some cases legislators have responded to new and complex technology policy issues with solutions more suited for the old economy. And as the innovation economy has become increasingly important, opposition to it from special interests has grown. Finally, the excitement that the press, pundits and decision makers showed toward the information technology (IT) revolution in the 1990s has all too often been replaced with an attitude of "IT doesn't matter." It is time to set the record straight—IT is still the key driver of productivity and innovation.

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