

# **ISC Digital Strategy Group**

## **Working Paper**

### **One to One technology in schools: Evidence from research literature**

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This summary briefly examines the research literature and draws on ‘reviews of reviews’ or meta-analyses, technical government reports, experimental and case study reports. The purpose is to ask:

- What major 1-2-1 projects have taken place
- What problems/roadblocks did these projects reveal
- What promoted successful adoption in these projects
- What was the impact on learning in these 1-2-1 projects (and if possible, why)
- What lessons can be learnt from unsuccessful projects?

This review is intended for use as a tool to promote discussion, offering insights from other contexts and settings. This may be of particular use to schools starting their one-to-one or BYOD journeys. While reasonable efforts to review the available scholarly literature have been made, no guarantees of completeness are given.

# 1. Executive Summary

- 2.1 1-2-1 projects are widespread, throughout the USA, Australasia, and some European countries. These encompass whole states, e.g. Maine, New South Wales, and smaller school systems(e.g. equivalent to LEAs).
- 2.2 The impact on learning is often poorly measured however rigorous studies show differences across age, gender and subject, indicating that one size does not fit all.
- 2.3 The effect size is, on average, medium/moderate when compared to Hattie's list of effect sizes; however, this average hides a very wide variety of results. Some implementations of 1-2-1, when well-planned and targeted, achieve an effect size in Hattie's 'zone of desired effects'. Done badly, some 1-2-1 projects have negatively impacted learning.
- 2.4 There is no one 'magic bullet' to successful uptake and impact on learning. Instead a range of factors are responsible. These include:
  - 2.4.1 Long lead times, enabling widespread consultation, planning, and training
  - 2.4.2 Effective technical support, demand for which will remain constant. Unresolved technical problems quickly result in teacher/student non-compliance
  - 2.4.3 Projects which are driven by pedagogical vision and learners' needs, adjusted for age/subject.
  - 2.4.4 Extensive ongoing training and curriculum development resources (time etc) which helps teachers and departments, reorient their pedagogical practices and curriculum planning
  - 2.4.5 Training and support which builds teachers' confidence with technologies
  - 2.4.6 Appropriate content has been linked to successful impact
  - 2.4.7 Home-school links, and appropriate home use of laptops
  - 2.4.8 Involvement of students and parents

## 2. Widespread adoption

In 2007, it was estimated that 25% of all American school districts had implemented some form of 1-2-1 computing initiative, with a further quarter planning 1-2-1 by 2010 (Warschauer, Cotten, & Ames, 2011) across states including Georgia, Florida, Kansas, Louisiana, Maine, Massachusetts, Michigan, Missouri, New Hampshire, Pennsylvania, and South Dakota. Other jurisdictions, particularly Australia NSW, have also implemented 1-2-1.

- 2002 - Maine, USA. All 7<sup>th</sup> grade pupils given laptop and internet access.
- 2004-2008 Texas – Middle Schools Technology Immersion Pilot – 42 middle schools (n=7,594 pupils) followed over four years, with matched control groups.
- 2008-2010 Birmingham, Alabama. 15,000 laptops for grades 1 through 5. Notable for its project failure.
- 2008 - 2010 New South Wales, Australia. One laptop per pupil in years 9 to 12

Despite the widespread adoption of 1-2-1 technology, the research literature has a shortage of high-quality impact research – e.g. experimental studies which compare impact against control groups and take account of baseline factors (Zheng, Warschauer, Lin, & Chang, 2016). Where such studies exist, they show evidence for small to medium effect sizes; these vary by age/subject/activity and highlight the importance of careful implementation and follow-up. Boys have demonstrated larger gains than girls (Fleischer, 2012).

In addition to impacts on standardised test scores, the benefits attributed to 1-2-1 programmes include positive impacts on pupil motivation, attendance, and discipline. In Maine student attendance improved 7.7% and disciplinary referrals decreased by 54% (Holcomb, 2009), with similar improvements for 9<sup>th</sup> and 10<sup>th</sup> grade pupils in Alabama (Intel Inc, 2008) and for discipline, but not attendance, in disadvantaged Texan middle schools (Shapley, Sheehan, Maloney, & Caranikas-Walker, 2009). These results reflect general agreement in the literature (NSW Department of Education and Training, 2009), although counter reports show cases of ‘off-task’ disruptive behaviour simply going online (and thus appearing quiet).

There is also evidence that 1-2-1 can have a modest impact on pupils’ adoption of 21<sup>st</sup> Century learning skills.

### 3. Potential Roadblocks

Repeated papers highlight the importance of consultation with stakeholders in an extended ‘pre-implementation’ phase of one year. When consulting with teachers (Zheng et al., 2016), their initial fears included:

- limited technology skills,
- lack of sufficient technical support,
- uncertainty about ways in which the technology would affect learning
- fear of losing control in the classrooms

Other roadblocks include:

- Teacher frustration has resulted when technology is perceived to drive change, rather than changes which is pedagogically driven. Such frustration can lead to non-compliance.
- Teacher perceptions and beliefs: A pilot study in a Singapore high achieving boy’s middle school, saw laptops go unused as teachers privileged exam prep and direct instruction (Towndrow & Vaish, 2009). In this pilot, pupils’ adoption of technology was inhibited by their teachers’ values and beliefs (Towndrow & Fareed, 2015). Other studies have highlighted a lack of teacher consultation as a barrier to uptake (Zheng et al., 2016).
- A belief that pupils are ‘digital natives’ and will not need training or guidance, when in fact pupil skills are variable (Harper & Milman, 2016; Heath, 2017; Peterson & Scharber, 2017a; Warschauer et al., 2011).
- Lack of home use of technology – pupils that do not use their laptops at home take much longer to complete laptop tasks in lessons, causing classes to fall behind. (Peterson & Scharber, 2017a)
- Pupil distraction / self-control - students themselves have reported concerns about the opportunity for becoming distracted and engaging in off-task activities (Lei & Zhao, 2008; Towndrow & Fareed, 2015) – although reviews highlight the importance of effective training of pupils and behaviour management strategies.
- Exam driven curriculum – in the NSW 1-2-1 project, students sitting public exams reported a drop-off in use of laptops; this matched teachers’ reduced laptop use in exam level classes (Howard & Mozejko, 2013). This was attributed to teachers’ and pupils’ views of learning.
- Parents – in a pilot for one Midwestern middle school (231 students), parent satisfaction was significantly correlated with their belief that they could handle related problems (e.g. too much screen time). Similarly parents’ concerns also arose from classroom based issues: a preference for direct-instruction, perceived needs of exam classes and the in-class distractions offered by laptops (Lei & Zhao, 2008). In a different US pilot, parents became increasingly

concerned about problems connected to the social and academic use of laptops, both at home and school, where they hoped for innovative applications of technology in the classroom. (Jin & Schmidt-Crawford, 2017)

- A lack of appropriate digital content has hampered adoption (Penuel, 2006)

Multiple studies highlight technical barriers arising from the dynamic and fast changing nature of technology:

- insufficient and inflexible technical support which is sustained over time
- outdated school Internet filters blocking student access to useful websites (resolved via media education rather than filters)
- power/charging issues
- Increasing technical problems as laptops age, leading to increased disruption and behaviour management issues.
- Reliable Internet access is key (Peterson & Scharber, 2017a)

Recommendations arising from the literature are given in italics, as below:

*R: All students using 1-2-1 devices, must attend additional training, including ‘top-up’ training. This could take the form of an induction day, prior to the start of school, each year.*

*R: It is important to take time, to win the ‘hearts and minds’ of teachers, addressing their concerns, and having on-going conversations about pedagogy and learning.*

*R: Identification of good content is important.*

*R: Practical infrastructural and support related issues cannot be avoided.*

## 4. Features of successful implementations

Prior to launching their one-to-one initiative, the New South Wales Department of Education and Training reviewed the literature and found the following were key features of successful projects:

- Engaging with teachers' attitudes and beliefs about technology and pedagogy (at a general and subject level).
- clear vision and leadership at school and department level
- appropriate classroom management strategies,
- technical support, and
- ongoing professional development

Teachers' beliefs and instructional approaches are believed to be crucial to the effective uptake and integration of technology in teaching and learning (Howard & Mozejko, 2013; Peterson & Scharber, 2017a). Working with colleagues to envision how laptops will aide learning is key.

*R: INSET must incorporate department/subject based training and planning needs*

Pupils' home use of laptops was a strong indicator of learning gains in school writing / reading (particularly shown by the Texas pilot) (Shapley, Sheehan, Maloney, & Caranikas-Walker, 2010), however without in-school adoption, the Birmingham, Alabama, project showed laptop home use languishes (Zheng et al., 2016). This gives rise to two recommendations.

*R: Train pupils on how to effectively use their laptops, both inside and outside lessons.*

*R: Ask departments to occasionally set homework which builds independent laptop skills, appropriate to their departmental area*

### Effective Consultation

Staff/faculty – Numerous reviews highlight the importance of a long lead time, for staff to be involved in decision making and planning. This includes devices, preferred learning platforms/tools, and implementation process (Peterson & Scharber, 2017a). Giving staff opportunities to air concerns, in advance, has been shown help teachers overcome both technical and pedagogical barriers (Heath, 2017).

*R: Over one academic year, invite departmental 'digital leaders' to half-termly meetings, and hold monthly informal lunch meetings for staff to discuss this 1-2-1 initiative*

Students – A successful pilot study highlights pupils co-designing their own 'digital citizenship' training which included: cyber-bullying, user agreements, digital identity and how to use laptops for learning. (Peterson & Scharber, 2017a). That students can usefully comment on the effective use of

laptops has been seen in Singapore (Towndrow & Fareed, 2015) and Colorado where 5<sup>th</sup>, 6<sup>th</sup> and 9<sup>th</sup> grade students revealed strong insights on the pros and cons of laptops as related to learning (Zheng, Arada, Niiya, & Warschauer, 2014).

*R Use one or more Student Council meetings to discuss 1-2-1 related issues and to launch an ongoing 'pupil eLearning working party'*

Parents – various pilot studies have shown parents to appreciate ongoing education and training, on managing and supporting their children using laptops (Jin & Schmidt-Crawford, 2017).

## **Support Staffing**

All initiatives had extensive support staffing, although this took a variety of forms. It is notable that support needs did not wane over time. Sometimes aging technology presented new challenges, while in other circumstances, people's needs were evolving. Support initiatives discussed in the literature include:

- eLearning coach/leader - A US pilot study highlighted the importance of an eLearning coach/leader. This role included liaising with parents, other teachers, liaison with administration/IT support, student training in 'digital citizenship' for 15 to 20 minutes per week (Peterson & Scharber, 2017a).
- Students as first line support;
- Coaches – The Maine project employed content specialists to help teachers locate digital resources integrate into specific subject areas (Silvernail & Lane, 2004) – this was also seen in visits to Singapore schools and is a feature of GDST schools.
- Rapid in-house for immediate support, and outside vendors for major problems (Penuel, 2006)

*R: A holistic plan for support be formulated, which incorporates pupils, existing staff and the use of external support agencies.*

## Ongoing Professional Development

Formal CPD has been a critical component in many large scale and small 1-2-1 projects (Penuel, 2006). Reported features of this CPD include:

- Focus on integrating laptops into instruction
- Ongoing access to coaches
- Informal support and help from colleagues
- Peer instruction and CPD co-authoring
- Focus on finding content rich resources
- A focus on becoming more ‘student-centred’

A further review (2004 – 2014) by Harper and Milman (2016) also showed:

- The importance of teachers’ perceptions about the role of technology which influences levels of technology implementation.
- The classroom adoption and impact of 1-2-1 varies by subject area, topic and activity. Therefore, successful programmes report CPD focussed on both (a) technology skills and (b) subject specific application of technology to learning.
- CPD must also equip/empower teachers to monitor/maintain behavioural issues (e.g. pupils misbehaving behind screens and going off task).
- A key reason for non-adoption was teacher perception that curriculum requirements do not match laptop pedagogies. Time is needed to re-examine/re-write units of work to incorporate changes.

Some successful projects reported a 12-month period pre-training period, including visits to other schools to determine ‘what works’ (Williams & Larwin, 2016). Staff input in to the planning and execution of 1:1 programmes has also boosted programme effectiveness. Expectations for frequency and use of technology in classrooms should be agreed and measured (*ibid*).

The importance of regular, relevant, and ongoing teacher CPD is perhaps the most common and urgent theme throughout the literature. In their review of ‘common challenges’ faced by schools across five districts (in the American Midwest), Topper and Lancaster (2013) found a range of ways in which schools implemented training. They found no shortcuts and it was the districts that provided time during the school day, with substitute teachers hired for regular, ongoing PD, which saw better integration of technology into subject area learning. Districts which relied upon training after school or during planning times were less likely to see meaningful technology integration.

In the Maine 1-2-1 initiative, success was linked to schools who nominated a ‘lead practitioner’ and had extensive CPD. The more resources a school put in to CPD, the better the adoption<sup>1</sup> (Morrell, 2012; Silvernail & Lane, 2004; Watters, 2015).

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<sup>1</sup> Although it is unfortunate that there was no way to show the impact of 1-2-1 laptops on standardised State tests

- R: Expectations and milestones be established at the outset, in consultation with staff and departments. Annual appraisals could be adjusted to include a section for 1-2-1 related targets.*
- R: Produce a report entitled “Our Learners”, which outlines what type of learners we think our students are (incorporating the views of students themselves), and how we want to them to enhance their learning with technology. This would engage staff (and student) views of pedagogy which are considered central to successful adoption of 1-2-1 initiatives. It may also be prudent to also consult parents.*
- R: Staff training must be sustained and ongoing. It will need to be extensive, addressing staff views of learning and students’ needs, across departments and ages.*
- R: Training needs fall in to two categories – pedagogical training, and skills training. Comprehensive strategies for both must be planned, across multiple delivery modes.*

### **Student involvement (technical)**

Students as ICT Advisors (with advanced support knowledge) have been a common feature of successful eLearning and ICT initiatives, in many countries. This worked well in Maine (Penuel, 2006), and the Midwestern USA (Peterson & Scharber, 2017b), and is very common in Australian/NZ schools. This has been a key initiative at similar schools receiving praise from ISI and other sources.

- R: Seek ways to promote student involvement, technical skills and ownership of 1-2-1*

## **Pedagogical initiatives**

Specific curriculum-based projects can foster appropriate staff and student uptake, of 1-2-1 technology. One such project is Project Hiller (Light, McDermott, & Honey, 2002) – students and staff applied to join project, which involved:

- Joint staff- student training
- Project based activities
- Developing multimedia resources for departmental projects
- Peer mentoring
- Flexible ways of working (as some schedules conflicted)

The outcomes included:

- Improved results on standardised tests
- Improved relationships between students and teachers
- Teacher expectations increased
- Pupil motivation and retention improved

*R We examine the introduction of specific projects, akin to Independent learning projects (aka EPQ), for those years who adopt 1-2-1. These projects should engage both pupils and staff, in learning appropriate use of 1-2-1.*

## 5. 1-2-1 impact on attainment

The most recent meta-analysis of 1-2-1's impact on standardised student attainment, summarises 65 peer-reviewed journal articles and 31 doctoral dissertations, from 2001 to 2015 (Zheng et al., 2016). This review demonstrates key points:

- Learning does benefit through the deliberate and purposeful application of 1-2-1, although the benefit is variable across the curriculum (and age ranges).
- Learning benefits take time to develop, with training, in the first year, for pupils and teachers.
- Some studies report an 'implementation dip' in the first year – presumably due to time being lost to laptop training.
- Impact on reading - limited evidence for little effect.
- Impact on writing – some evidence for a positive effect on students' writing performance in the area of ideas and content, organization, and style, but not in the area of conventions
- Impact on mathematics – varied by project, **but was linked to content**
- Impact on science – varied by sub-subject and was **linked to types of content** used (Crook, Sharma, & Wilson, 2015)

It is important to highlight the fact that meta-analyses report average effects. In a meta-analysis of covering 40 years of research and 1055 studies, Tamim and colleagues (2011) found an average effect size of 0.35 and is close to what Hattie (2009) believes 'desirable' (e.g. 0.4 or higher). However, it is possible that the figure of 0.35 underestimates the potential of 1-2-1 as it includes projects with negative impact, alongside those with larger positive impact.

With a thoughtful and well-planned implementation, it ought to be possible to effectively target the use of 1-2-1 to areas of large benefit; the key will be to match the use of technology to pupils' learning needs, across different subjects and ages. This principle is highlighted by results from the Maine 1-2-1 project (n=16,000) which showed large differences in the state-wide writing proficiency standard, depending upon how students used their laptops (effect size = 0.68).

*R: Departments and staff are expected and sufficiently resourced, to search the literature, meet with subject associations, and visit other schools, to explore the ways in which 1-2-1 can be best used in their subject areas.*

## 6. Unsuccessful projects

There are two projects which offer interesting lessons borne of unfavourable results.

The first, brief paper, highlights the impact of a 1-2-1 pilot in 24 Ohio schools (matched to similar control schools). Looking at results over a 5 to 8-year period showed no gains to learning. However, two points of interest emerged:

- Considering netbooks vs laptops / iPads – showed netbooks to be more successful.
- A sub-group of schools obtained consistently positive results, while a different subgroup showed consistently negative results – suggesting differences in implementation across the trial, and a need for greater care in implementation.

The second, major 1-2-1 initiative relates to schools in Birmingham, Alabama where some 15,000 pupils in grades 1 through 5 received a netbook. The project was judged a failure, and discontinued, after netbooks remained largely unused. The following are suggested as possible reasons (Warschauer et al., 2011):

- The project was highly politicised, driven by central priorities.
- Low levels of Internet access in classes
- Inadequate CPD (2 hours per teacher)
- No teacher-mentor programme (unlike neighbouring districts)
- Lack of technical support
- Technical inferiority of netbooks

## 7. Preparing for online exams

This section presumes that online exams are an inevitability. Reasons for this including cost, logistics, security, speed of marking, automated marking and ‘modernisation’. UK exam boards are already preparing for this, pending regulatory approval.

In 2009, Norway started trialling digital examinations, using pupil devices. This was later rolled out for all upper secondary pupils and is deemed a success. In personal discussion with Norwegian teachers, it is believed that pupils who make the most use of laptops, in classes and exam like scenarios, do better – with clear implications if pupils are to be ready for similar in the UK.

*R: We prepare for online exams, by progressively introducing online tests and end of year exams. This could be from a third-party provider, or from an in-house solution.*

Research based on international visits to independent schools in Australia and Singapore have shown online content and testing can reduce staff and student workload – once set up. These schools allocated significant resources (time) to the production of high quality resources in advance. UK schools which have appointed VLE staff, to set up tools for teachers, have seen widespread adoption and success. This is partly in response to the fact that many online resources do not appear to fit needs fully. There is however, potential to collaborate with various content providers.

*R: We commission a plan for the production of online testing materials and VLE like use, with adequate resourcing – perhaps for use in key departments where impact may be greatest.*

There is further evidence from varied studies that laptop uptake is influenced by pupils’ views of learning and the assessments they face (Harper & Milman, 2016; Howard & Mozejko, 2013) Those who make better use of technology in high-stakes years, are those with a background of using technology.

*R: Pupils must become proficient in technology use prior to entering year ‘high-stakes’ examination-based years. (e.g. years 10 through 13).*

Reviews of published literature have shown laptops may have a positive effect on students’ writing performance in the area of ideas and content, organization, and style (Zheng et al., 2016), however practice with digital skills is necessary.

*R: Pupils’ exam results in essay-based subjects, may benefit from the ability to redraft/ craft essays using ICTs, however specific training is required and takes time to learn. This favours implementation of technology in key stage three, or at the very least, one year prior to public exams.*

## 8. References

- Crook, S. J., Sharma, M. D., & Wilson, R. (2015). An Evaluation of the Impact of 1:1 Laptops on Student Attainment in Senior High School Sciences. *International Journal of Science Education*, 37(2), 272–293. <https://doi.org/10.1080/09500693.2014.982229>
- Fleischer, H. (2012). What is our current understanding of one-to-one computer projects: A systematic narrative research review. *Educational Research Review*, 7(2), 107–122. <https://doi.org/10.1016/j.edurev.2011.11.004>
- Harper, B., & Milman, N. B. (2016). One-to-One Technology in K–12 Classrooms: A Review of the Literature From 2004 Through 2014. *Journal of Research on Technology in Education*, 48(2), 129–142. <https://doi.org/10.1080/15391523.2016.1146564>
- Hattie, J. (2009). *Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement*. New York: Routledge.
- Heath, M. K. (2017). Teacher-Initiated One-to-One Technology Initiatives: How Teacher Self-Efficacy and Beliefs Help Overcome Barrier Thresholds to Implementation. *Computers in the Schools*, 34(1–2), 88–106. <https://doi.org/10.1080/07380569.2017.1305879>
- Holcomb, L. B. (2009). Results & lessons learned from 1:1 laptop initiatives: A collective review. *TechTrends*, 53(6), 49.
- Howard, S., & Mozejko, A. (2013). *DER-NSW evaluation: Conclusions from the 2013 data collection*. Sydney: New South Wales Department of Education and Communities.
- Intel Inc. (2008). *Technology as a tool for system-wide transformation. The 21st Century learning initiative at Auburn City Schools. Part 3. Evaluating change: results and looking forward*. (White Paper). Intel. Retrieved from <https://www.intel.com/content/dam/doc/white-paper/education-21st-century-learning-environment-part-3.pdf>
- Jin, Y., & Schmidt-Crawford, D. A. (2017). Parents' Perceptions of the First-Year Implementation of a One-to-One Laptop Initiative in a Midwestern High School. *Computers in the Schools*, 34(1–2), 73–87. <https://doi.org/10.1080/07380569.2017.1293470>
- Lei, J., & Zhao, Y. (2008). One-to-One Computing: What Does it Bring to Schools? *Journal of Educational Computing Research*, 39(2), 97–122. <https://doi.org/10.2190/EC.39.2.a>
- Light, D., McDermott, M., & Honey, M. (2002). *The impact of ubiquitous portable technology on an urban school. Project Hiller*. NYC: Center for Children and Technology.
- Morrell, R. (2012, October 31). Maine's decade-old school laptop program wins qualified praise. Retrieved January 7, 2018, from <http://hechingerreport.org/maines-decade-old-school-laptop-program-wins-qualified-praise/>
- NSW Department of Education and Training. (2009). *One-to-One computing: literature review*. New South Wales Department of Education and Training, Curriculum K-12 Directorate.
- Penuel, W. R. (2006). Implementation and Effects Of One-to-One Computing Initiatives. *Journal of Research on Technology in Education*, 38(3), 329–348. <https://doi.org/10.1080/15391523.2006.10782463>
- Peterson, L., & Scharber, C. (2017a). Lessons From a One-to-One Laptop Pilot. *Computers in the Schools*, 34(1–2), 60–72. <https://doi.org/10.1080/07380569.2017.1296328>
- Peterson, L., & Scharber, C. (2017b). Supporting a 1:1 program with a student technology team. *International Journal of Information and Learning Technology*, 34(5), 396–408. <https://doi.org/10.1108/IJILT-06-2017-0049>
- Rana M. Tamim, Robert M. Bernard, Eugene Borokhovski, Philip C. Abrami, & Richard F. Schmid. (2011). What Forty Years of Research Says About the Impact of Technology on Learning: A Second-Order

Meta-Analysis and Validation Study. *Review of Educational Research*, 81(1), 4–28.  
<https://doi.org/10.3102/0034654310393361>

- Shapley, K., Sheehan, D., Maloney, C., & Caranikas-Walker, F. (2009). *Evaluation of the Texas Technology Immersion Pilot. Final Outcomes for a Four-Year Study (2004–05 to 2007–08)*. Texas Center for Educational Research (TCER). Retrieved from [https://etcjournal.files.wordpress.com/2010/07/etxtip\\_final.pdf](https://etcjournal.files.wordpress.com/2010/07/etxtip_final.pdf)
- Shapley, K., Sheehan, D., Maloney, C., & Caranikas-Walker, F. (2010). Evaluating the Implementation Fidelity of Technology Immersion and Its Relationship with Student Achievement. *Journal of Technology, Learning, and Assessment*, 9(4). Retrieved from <https://eric.ed.gov/?id=EJ873678>
- Silvernail, D. L., & Lane, D. M. (2004). *The impact of Maine's one-to-one laptop program on middle school teachers and students*. Maine Education Policy Research Institute (MEPRI), University of Southern Maine.
- Topper, A., & Lancaster, S. (2013). Common Challenges and Experiences of School Districts That Are Implementing One-to-One Computing Initiatives. *Computers in the Schools*, 30(4), 346–358.  
<https://doi.org/10.1080/07380569.2013.844640>
- Towndrow, P., & Fareed, W. (2015). Growing in digital maturity: students and their computers in an academic laptop programme in Singapore. *Asia Pacific Journal of Education*, 35(4), 438–452.  
<https://doi.org/10.1080/02188791.2013.876387>
- Towndrow, P., & Vaish, V. (2009). Wireless laptops in English classrooms: a SWOT analysis from Singapore. *Educational Media International*, 46(3), 207–221.  
<https://doi.org/10.1080/09523980903135335>
- Warschauer, M., Cotten, S. R., & Ames, M. G. (2011). One Laptop per Child Birmingham: Case Study of a Radical Experiment. *International Journal of Learning and Media*, 3(2), 61–76.  
[https://doi.org/10.1162/ijlm\\_a\\_00069](https://doi.org/10.1162/ijlm_a_00069)
- Watters, A. (2015, March 2). From Lunchboxes to Laptops: How Maine Went One-to-One. Retrieved January 7, 2018, from <http://hackeducation.com/2015/03/02/maine-laptops>
- Williams, N. L., & Larwin, K. H. (2016). One-to-One Computing and Student Achievement in Ohio High Schools. *Journal of Research on Technology in Education*, 48(3), 143–158.  
<https://doi.org/10.1080/15391523.2016.1175857>
- Zheng, B., Arada, K., Niiya, M., & Warschauer, M. (2014). One-to-one laptops in K-12 classrooms: voices of students. *Pedagogies: An International Journal*, 9(4), 279–299.  
<https://doi.org/10.1080/1554480X.2014.955499>
- Zheng, B., Warschauer, M., Lin, C.-H., & Chang, C. (2016). Learning in One-to-One Laptop Environments: A Meta-Analysis and Research Synthesis. *Review of Educational Research*, 86(4), 1052–1084.  
<https://doi.org/10.3102/0034654316628645>